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This report presents the results of a demonstration of the effectiveness of debris basins in controlling solids in water discharging from surface mine operations. A site in Eastern Kentucky was selected for study in an area where very little erosion-causing activity has occurred and where surface mining was to be initiated. An adjacent "virgin" watershed was also selected to provide background data on water quality where man's activities have been very limited.

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DEMONSTRATION OF DEBRIS BASIN EFFECTIVENESS IN SEDIMENT CONTROL

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the pollutional impact on our environment and even on our health often requires that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-CI) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This study was conducted to determine the effectiveness of sedimentation ponds, as built, in the removal of suspended solids discharged in the runoff from lands disturbed by a typical surface mine in eastern Kentucky. Inadequate pond performance under high flows is due partly to poor construction and lack of maintenance. The information in this report should be of interest to any program concerned with suspended solids control in runoff. The permanent installation, interruption in mining activities and the amount of coal left exposed and not removed makes the subject site a prime candidate for further developmental work on sediment ponds.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

PREFACE

The concept of this project has changed considerably since its beginning in 1971. The pre-feasibility[1] and feasibility phases[2] provided background water quality and other information. When the study sites were accepted as feasible, strip mining was complete.

The excellent cooperation of Beth-Elkhorn Corporation saved the only site remaining from the feasibility study, Rhoades Branch. Rising equipment costs and necessary changes to the monitoring system dictated changes to the scope of work. It was decided to concentrate in this one basin with a permanent installation, a fortuitous decision, in light of subsequent events. Only a small portion of the area was mined before mining halted as the result of the UMWA coal strike of 1977 and no further mining occurred. Monitoring was continued until the end of March, 1979, when the station was turned over to the Department of Civil Engineering, University of Kentucky for continuing studies at the request of Kentucky Department for Natural Resources and Environmental Protection. The available reserves remaining in the basin make this area a prime candidate for future mining, and new, engineered sediment ponds will be required.

The permanent installation and the prospect of future mining makes this area a working laboratory for sediment pond development work, with the continued cooperation of Beth-Elkhorn Corporation.

ABSTRACT

This report presents the results of a demonstration project on the effectiveness of debris basins in controlling solids in water discharging from a surface mining operation in Eastern Kentucky. The selected site included two watersheds in which very little erosion causing activities had occurred but with strip mining scheduled in one (Rhoades Branch).

Mining activities began with construction of a haulroad and nine debris basins in August, 1976, and were halted by the UMWA strike in December, 1977. During this period, only four of the basins received run-off from disturbed areas. Monitoring showed that efficiency was much lower during storm events than during normal flows, due in part to poor construction and maintenance practices. The efficiency decreased with time because accumulated sediment was not removed from the ponds.

This report was submitted in fulfillment of Grant Number S-801276 by L. Robert Kimball and Associates, Consulting Engineers and Architects, Ebensburg, Pennsylvania, under the partial sponsorship of the Environmental Protection Agency. Work was completed as of December, 1979.

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CONVERSION TABLE

Measurement	Metric Equivalents: Divide Unit	Symbol	BY	English Equivalents: To Obtain Unit	Symbol
Length	centimeter	cm	2.54	inch	in
	meter	m	0.3048	foot	ft
	kilometer	km	1.61	mile	mi
Area	square meter	m^2	0.836	square yard	sy
	hectare	ha	0.405	acre	ac
	square kilometer	km^2	2.59	square mile	-
Volume	cubic meter	m^3	0.0283	cubic foot	cf
	cubic meter	m^3	0.7645	cubic yard	cy
	liter	l	3.785	gallon	gal
Mass	kilogram	kg	0.4536	pound	lb
	tonne	t	0.9074	ton	-
Flow	liter per second	l/s	0.06309	gallons per minute	gpm
	cubic meter per second	m^3/s	0.02832	cubic foot per second	cfs
	cubic meter per second	m^3/s	0.0438	million gallons per day	mgd

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SECTION 1

INTRODUCTION

GENERAL

Throughout the Appalachian coal region of the eastern United States, surface mining has become an important method for extracting coal. Surface mining involves massive earth moving operations that subject large areas to accelerated erosion. The eastern Kentucky coal field was selected as the area of study because it represents the average environment, topography, land use, and mining methods which occur in the region. An important factor in the selection of the eastern Kentucky coal field is its steeply-sloping terrain which causes rapid runoff of surface water, intensifying erosion in disturbed areas.

This erosion can be minimized, decreased, or controlled by a number of onsite or offsite methods. Runoff control, soil stabilization, vegetation establishment and sediment control are alternatives used by the mining industry.[3] Sedimentation ponds (debris basins) provide a secondary line of defense against possible offsite sediment pollution.

BACKGROUND

In October, 1971, an application was submitted by the Office of Planning and Research, Kentucky Department for Natural Resources and Environmental Protection to the U.S. Environmental Protection Agency requesting a demonstration grant to define the effectiveness of debris basins as built by surface mine operators for sediment control in steep sloping terrain. Following grant approval, the Department entered into a service contract with L. Robert Kimball Consulting Engineers (subsequently L. Robert Kimball and Associates) effective January 17, 1972, to perform engineering work and services related to the project.

The initial phase of the project was a prefeasibility study and report completed in 1972.[1] This reduced level of effort study resulted in the selection of three sites where surface mining would be initiated in undisturbed isolated watersheds in coordination with the beginning of the demonstration study phase of the project. By written agreement, the mine operators agreed to coordinate mining activities so construction and water quality data could be collected.

The next phase of the project culminated in a report completed in 1975[2] establishing the feasibility of the proposed demonstration project.

Feasibility was established by:

1. Reviewing the history of surface mining methods and procedures, the debris basin construction practices in the industry, and the ever-increasing number of active surface mines in the region.

2. Determining the jurisdictional framework (legal authority) through which the demonstration project could be carried out.

3. Collecting and analyzing data to assess the interrelationship of geology, topography, soils, hydrology and water quality of the selected sites.

4. Developing in sufficient detail an efficient monitoring program.

5. Selecting monitoring equipment and the design of monitoring stations.

6. Developing a proposed schedule and demonstration format to assure satisfactory completion of the project.

Several changes were made to the demonstration project following the feasibility report submission.

1. One of the selected sites was eliminated because of pending litigation between the coal company and the U.S. Army Corps of Engineers.

2. The monitoring equipment and monitoring station design originally proposed in 1971 were inadequate for the selected site and required a new design.

3. Spiraling equipment and construction costs caused a decrease in the number of monitoring stations, until only one primary station could be built with the funds allocated. Monthly grab samples and flow measurements were used to supplement, calibrate and rate the monitoring station, and to provide additional data.

4. This primary station was built as a permanent installation, with a concrete weir and monitor housing and electric hook-up. This decision was fortuitous because of the length of monitoring and also the interruption in active mining in the valley.

This report evaluates the information and data derived from implementation of the demonstration project to determine the effectiveness of debris basins in reducing the sediment load in streams during and after a surface mining operation.

GENERAL DESCRIPTION OF THE PROJECT

Two similar adjacent watersheds in eastern Kentucky were selected for study in areas where very little erosion causing activity has occurred, and with mining proposed in only one valley (Rhoades Branch). The adjacent control

watershed (Dick Branch) was selected to provide background data on water quality where man's activities have been very limited.

The Rhoades Branch - Dick Branch Study Area (Figure 1) constitutes a small portion of the eastern Kentucky coal field in the upper reaches of Rockhouse Creek, a tributary to North Fork of the Kentucky River. Although coal was mined in local areas within this watershed, no surface mining had been done in the study area prior to its selection for this demonstration.

Permission to establish the monitoring station in Rhoades Branch was obtained from Beth-Elkhorn Corporation, the surface and mineral owner. Beth-Elkhorn Corporation also pledged the cooperation of its contract strip-miner, Tackett and Manning Corporation, who had earlier signed a cooperation agreement with KDNREP.

Tackett and Manning submitted a mining plan for Rhoades Branch to KDNREP in June, 1975, but indicated that a change in the coal market was necessary before they would begin mining. Construction of the monitor housing and weir was completed in March, 1976 and electric power was installed in June. Equipment installation was complete by August 31, 1976. In August, 1976, Tackett and Manning constructed an access and haul road in Rhoades Branch. They also constructed the debris basins as shown on their mining plan. These small earthen basins were designed in the field by the bulldozer operator, a common practice at that time in this area. Very little mining was done in Rhoades Branch until March, 1977, although a head-of-hollow fill was constructed earlier. Mining continued through the spring and summer of 1977. By the fall of 1977 the main sediment basin on Rhoades Branch upstream of the monitoring station had completely filled and rather than clean the pond, the company built a dumped rock barrier across the stream 52 meters (170 feet) upstream of the monitor station.

Mining ceased with the advent of the UMWA strike, December 6, 1977 and was not permitted to continue at the conclusion of the strike, March 27, 1978, because Tackett and Manning did not sign the new contract and Beth-Elkhorn Corporation did. The disturbed area was hydroseeded in August, 1978 and monitoring continued through March, 1979.

PURPOSE OF THE PROJECT

The project demonstrated the effectiveness of debris basins, as built in eastern Kentucky, in reducing the sediment load from strip mining disturbances to Rhoades Branch. It provided information on the change in water quality in Rhoades Branch during and after mining when compared to Dick Branch and also provided information on common mining practices, in 1976 and 1977.

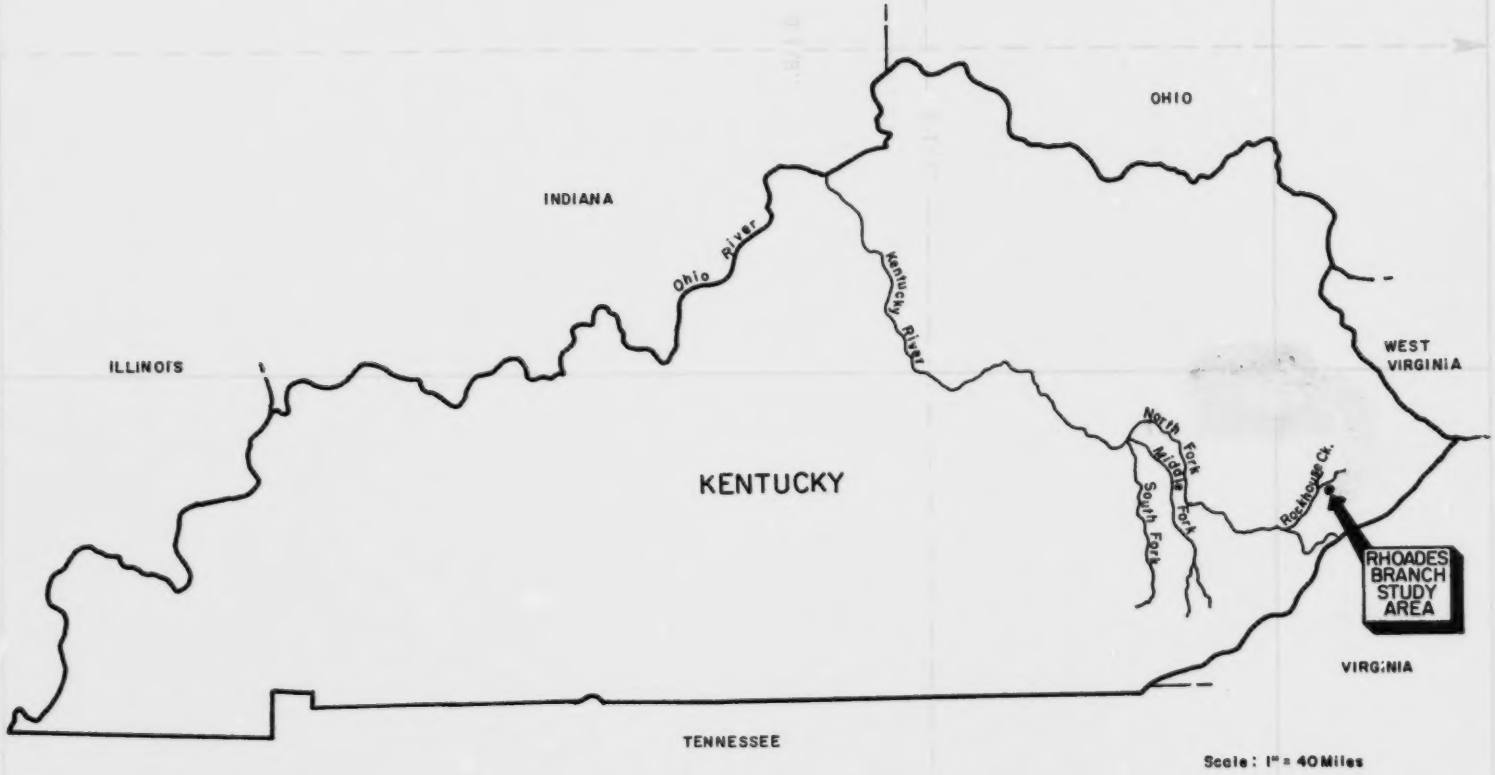


Figure 1. Location of Study Area

SECTION 2

CONCLUSIONS

A system of sediment basins, as built in the Rhoades Branch study area, was studied to determine the efficiency over the life of a surface mining operation. This study, like others[4][5] found that the efficiency of removal of suspended solids was much lower under high flow conditions than under low flows. And, because of lack of maintenance, efficiency decreased with time. None of the ponds, as built, met the storage capacity requirements of the Kentucky Division of Reclamation, 610m^3/ha (0.2 acre-ft per acre) of disturbed area in the watershed.[6]

With time, efficiency decreased due to lack of maintenance, no clean-out of the ponds, reduced sediment storage and shorter retention time. Previous sedimentation, and no clean-out caused the ponds to become sources of sediment for downstream transport. On the whole the pond system delayed off-site sedimentation but did not prevent it.

The pond system consisted of in-stream ponds, where a bulldozer was used to excavate a portion of the stream channel, using the excavated material to form the downstream embankment. The principal spillway was usually a corregated metal pipe, with the open channel emergency spillway located at a slightly higher elevation on the opposite side of the embankment. Once the ponds were constructed, they were not maintained. Clogging of outflow pipes by floating debris and acccumulated sediment caused excess use and rapid deterioration of the emergency spillway and embankment and short circuiting of the ponds.

Two major factors contributing to the poor efficiency of the pond system were; the ponds were not built in conformance with the required plans and specifications of the regulatory agency, and no maintenance was performed after the ponds were built.

The unplanned stoppage of mining in Rhoades Branch indicates that future mining within the basin will be done. New ponds, designed according to existing regulations will be required before this mining begins. The permanent monitoring installation coupled with the high likelyhood of future mining makes this area a prime candidate for future sediment basin design demonstration projects.

The exposure of fresh rock surfaces after mining began resulted in rapid chemical weathering. Significantly increased concentrations of sulfates,

hardness and conductivity occurred in Rhoades Branch during mining. Although the entire mining area was hydroseeded in August, 1978, little change in the rate of weathering was apparent by the end of the study period March, 1979. Sulfates, hardness and conductivity values have increased by factors of 4.5, 3.5 and 3, respectively over their premining values.

A significant amount of raw data in the form of strip chart records and partial computer print-outs has been accumulated. It is beyond the scope of work of this project to manually manipulate this data to determine trends other than those described in the text.

The poor overall performance of sediment basins may be attributed to:

1. The ponds did not have the required storage capacity.

2. No maintenance was performed.

3. The ponds were not cleaned out when they were filled.

4. The outlet pipes became clogged resulting in excessive use and deterioration of the emergency spillway.

5. No provision was made for removing the pond embankment and contents when no longer operable.

SECTION 3

RECOMMENDATIONS

It was apparent during field work that maintenance and cleaning of the ponds was necessary but ignored. The importance of maintenance should be addressed and emphasized to inspection officials. A schedule for cleaning and disposition of dredged material should be required when the sediment basin plans are submitted. Pond embankments should be removed and properly disposed when mining has ceased to prevent gradual deterioration and eventual failure, years after mining is complete.

The required storage area is difficult to construct because of terrain constraints in the study area, even with ponds in a series. To overcome this problem several techniques and operating procedures should be encouraged, including "at-source" controls such as minimizing disturbed areas, providing vegetative buffers and sediment traps. Methods to slow the velocity of runoff before it reaches the sediment ponds will decrease the amount and size of suspended sediment.

Following the field work in this study, the permanent station was turned over to the Department of Civil Engineering, University of Kentucky, so monitoring would be continued, at least intermittently. The interruption in mining strongly indicated that future mining will occur, and, with changes regarding sediment basin design, occurring due to previous studies and the Office of Surface Mining Regulations, new basins would be constructed, and should be monitored.

The monitoring equipment has been in operation since September, 1976, with random stoppages from extended power outages and during low or zero flow conditions. A general overhaul and equipment reconditioning should be performed before mining begins again.

Contacts and cooperation with Beth-Elkhorn Corporation should be renewed and the Permit Application Section of the Division of Reclamation should be encouraged to provide any new permits for mining in the Rhoades Branch area.

SECTION 4

THE STUDY AREA

THE WATERSHEDS

Rhoades Branch

The Rhoades Branch watershed is located in Letcher County east of Deane, in the northeast quadrant of the Mayking, Kentucky 7.5 Minute Topographic Quadrangle (Figure 2). Access to the site is provided by Kentucky Route 317 in the valley of Rockhouse Creek and an abandoned county road south from an intersection with Route 317 approximately 1500 m east of the intersection of Kentucky Route 7. This site was selected to replace the Marty Corporation site (Site 2 in the Pre-Feasibility Report).

The watershed consists of approximately 104 hectares (257 acres) upstream from the monitoring station. An abandoned deep mine is present near the valley mouth in the Upper Elkhorn No. 3 coal zone. An abandoned almost demolished, loading tipple was present in the upper reaches of the valley in the Amburgy coal zone. Second growth trees covered ninety (90) percent of the area. Ridge top elevations bounding the watershed range from 581 m (1,906 feet) to 683 m (2,240 feet). Hillside slopes range from 15% (14°) to 71% (36°). Rhoades Branch, 1525 m (5,000 feet) long, begins as intermittent springs at approximate elevation 531 m (1,710 feet) and flows out of the valley at elevation 390 m (1,280 feet). The overall gradient of the stream is 8.6%. Rhoades Branch is uninhabited.

A total of four coal seams in four coal zones are exposed as outcrops within the watershed. In ascending order these are a coal bed in the Upper Elkhorn No. 3 coal zone, elevation 425 m (1,400 feet); Amburgy coal, elevation 485 m (1,590 feet); Whitesburg coal, elevation 534 m (1,750 feet), and the Fire Clay coal zone, elevation 549 m (1,800 feet).

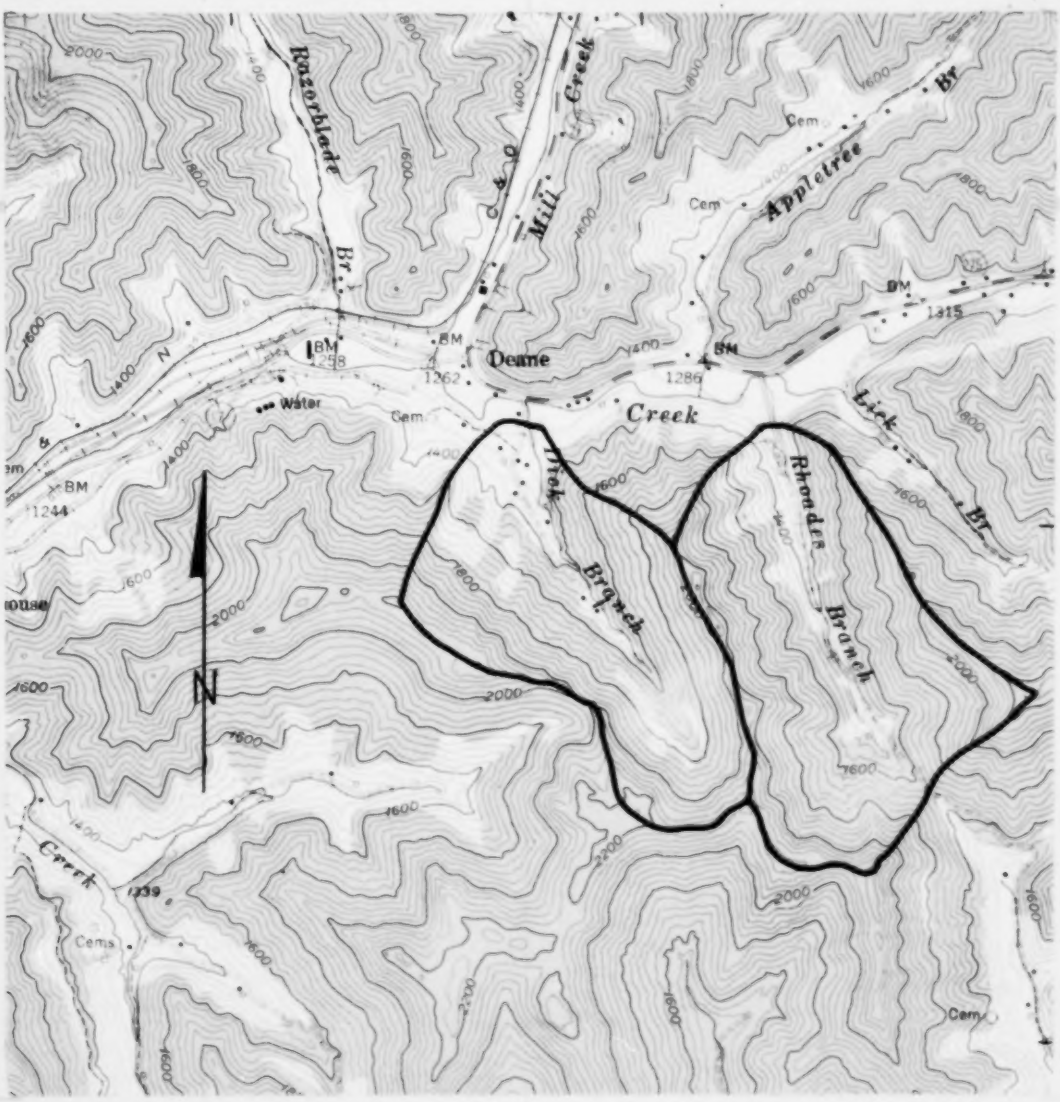
Dick Branch - Control Stream for Rhoades Branch

Dick Branch is located in the hollow immediately to the west of Rhoades Branch. Access to the stream is provided by Kentucky Route 317 approximately 300 m southeast of its intersection with Kentucky Route 7.

The watershed consists of approximately 95 hectares (235 acres) upstream from the proposed monitoring location. More than ninety (90) percent of the area is forested. Ridge top elevations bounding the watershed range from 604 m (1,980 feet) to 683 m (2,240 feet).

Figure 2. THE STUDY AREA

Base map is a portion of the U.S.G.S. 7.5 minute Mayking Quadrangle, with contours based on the English system of measurement. (scale 1"=2000' contour interval 40 feet) A metric conversion table is found on page viii.



Hillside slopes range from 25% (14°) to 71% (36°). Dick Branch, 1463 m (4,800 feet) long, begins as intermittent springs at approximate elevation 482 m (1,280 feet) and flows out of the valley at elevation 298 m (987 feet). The overall gradient of the stream is 6.3%. Five to seven families lived in the Dick Branch watershed during the study period.

This area contains the same coal outcrop as reported for the Rhoades Branch watershed. Both streams are tributaries of Rockhouse Creek which flows into the North Fork Kentucky River, Figure 1.

CLIMATE

The climate is typical of a temperate zone at 37°N latitude. The average yearly temperature is 14.5°C. Average precipitation is 1100 mm with the greatest monthly precipitation recurring in July (128 mm) and March (110 mm). Average monthly and annual records are based on the Pikeville, Kentucky records of the National Oceanographic and Atmospheric Administration (NOAA).

Appendix A contains the daily precipitation and flow data obtained during the project. Before September 21, 1977, the values are the weighted averages of the Burdine and Jeremiah stations (NOAA), located 15 km east and 17 km southwest of the study area, respectively. After that date, a tipping bucket type rain gage with an electronic totalizer was installed at the monitoring station. The above stations were used only when the rain gage became inoperable. Cumulative monthly precipitation is shown on Figure 3. The largest monthly precipitation occurred in December, 1978 (198 mm) with a majority occurring in the period December 3rd through December 9th when 145 mm were recorded. The lowest monthly precipitation was 32.5 mm in February, 1978. The largest precipitation in a single day was on April 4, 1977 (67mm).

Total precipitation for the study period was 2614 mm, divided rather evenly between the 1977 and 1978 calendar years as 1172 mm and 1174 mm respectively. Based on the Pikeville, Kentucky average annual precipitation (1100 mm) the study years were about 7% wetter than average.

GEOLOGY

The study area, located in the northeast quadrant of the Mayking 7.5 min. Quadrangle, is in the stratigraphic sequence of the Breathitt Formation of Lower and Middle Pennsylvanian Age. This sequence is composed, in decreasing order of abundance, of sandstones, siltstones, shales, coals and underclays. The sandstones are light to medium gray, very fine to medium grained and in part crossbedded. Siltstones and shales are medium dark to dark gray, locally containing limestone concretions and occasional siderite nodules. The shales grade down to clayey shales above the coal beds. The beds are nearly horizontal, dipping very gently to the northeast at about 11.4 meters/kilometer (60 feet to a mile).[7]

Three mineable coal zones are present in the study area. The Upper Elkhorn No. 3, at elevation 425 m (1,400 feet), near drainage was previously deep mined. The Amburgy coal at elevation 485 m (1590 feet), exposed during haulroad construction, is too thin, 30.5 cm (12 in.), to be mined in the study

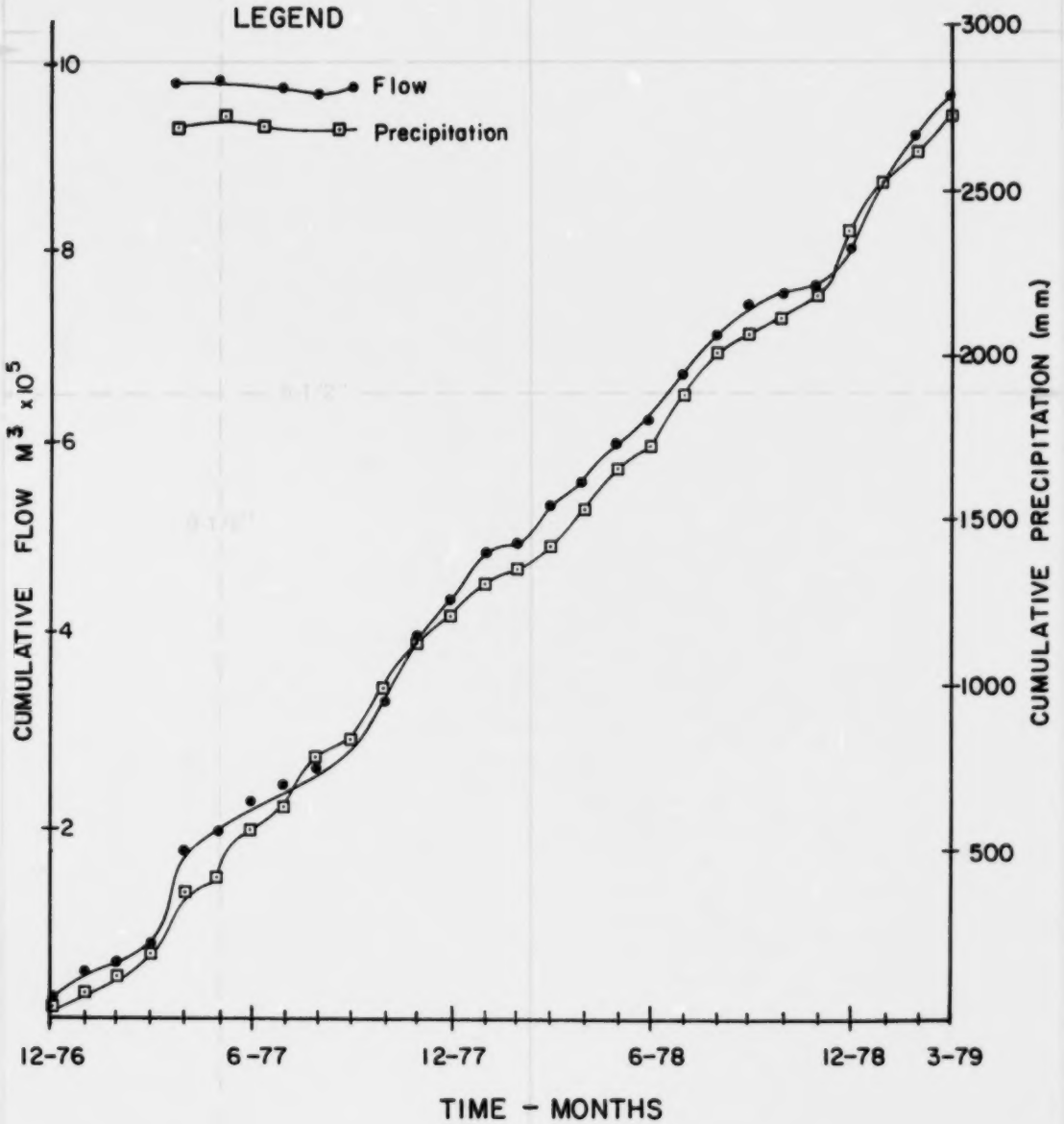


Figure 3. Cumulative flow and precipitation by month for the Rhoades Branch Site.

area. The Whitesburg coal, elevation 534 m (1,750 feet) is about 91 cm (36 in) thick and the Fire Clay coal, elevation 549 m (1,800) feet) averages 102 cm (40 in).

WEIR AND MONITORING EQUIPMENT

Figure 4 shows the weir and monitoring station near the end of construction (Spring, 1977). The metal plate used to make the weir sharp-crested had not been installed. The road in the background is the abandoned county road. The haulroad constructed in August, 1977 was located nearer to the valley side to the right of the Figure. Vandalism during the feasibility study dictated the complete enclosure of all instrumentation.

Weir

The weir consists of a 30.5 cm (1 foot) 90° V-notch and a 2.4 m (8 foot) rectangular portion, classified as a sharp-crested, suppressed weir. Flow measurements of Rhoades Branch, using a Teledyne-Gurley flowmeter provided the rating curve shown as Figure 5. The rating curve closely follows the rating curve for compound weirs developed by the Bureau of Reclamation[8]. That formula adapted to the metric system is:

$$Q = 0.852H^{1.72} - 0.04248 + 4.442h^{1.5}$$

Where Q = discharge in cubic meters per second

H = head above V-notch in meters

h = head above rectangular portion of weir in meters.

The head was measured by a water level recorder using a float in a stilling well inside the monitor station.

Flow

Total flow through the weir was determined by summation of average daily flows. Cumulative flow is also shown on Figure 3. When the daily fluctuation at the weir was more than 5 cm (2 in.), the daily flow was subdivided as necessary to obtain the storm profile. Total flow for the day was determined from the storm profile. On days for which no flow was recorded because of equipment breakdown, the flow was estimated from several relationships of flow versus precipitation for the Rhoades Branch area. These relationships were developed for summer (May 1 to October 31) and winter conditions of runoff and were divided into several flow ranges based on the previous day's flow. Linear equations were generated from the existing data in each flow range to estimate the flow for Rhoades Branch. These equations are:

Flow Range (m^3/sec)	Summer
0.0 to 0.00283	$Q = -0.0002 + 0.00058P + Qp$
0.00283 to 0.00566	$Q = -0.0006 + 0.00069P + Qp$
0.00566 to 0.01133	$Q = -0.0015 + 0.00105P + Qp$
0.01133 to 0.02265	$Q = -0.0045 + 0.00120P + Qp$

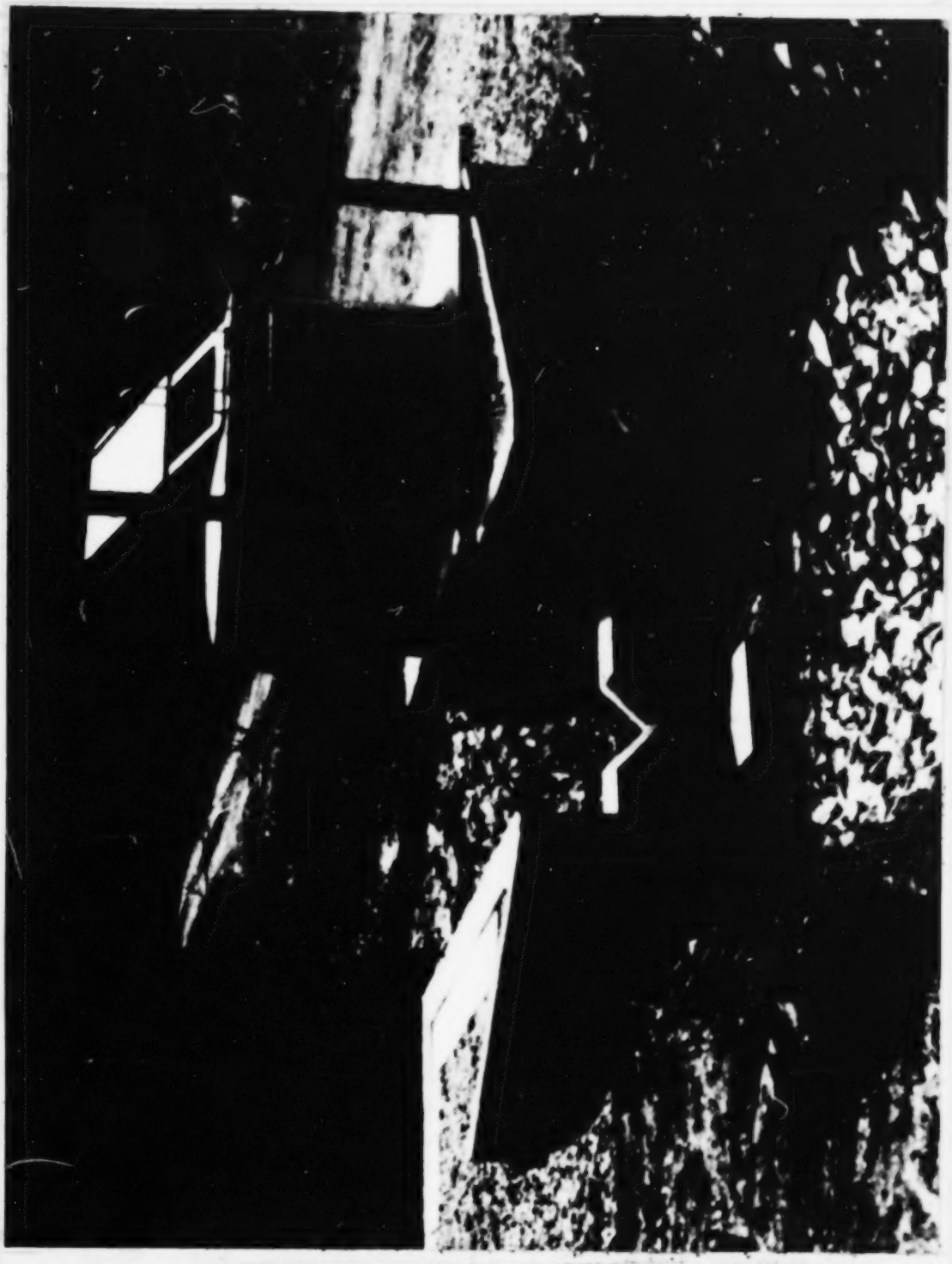


FIGURE 4 WEIR AND MONITORING STATION

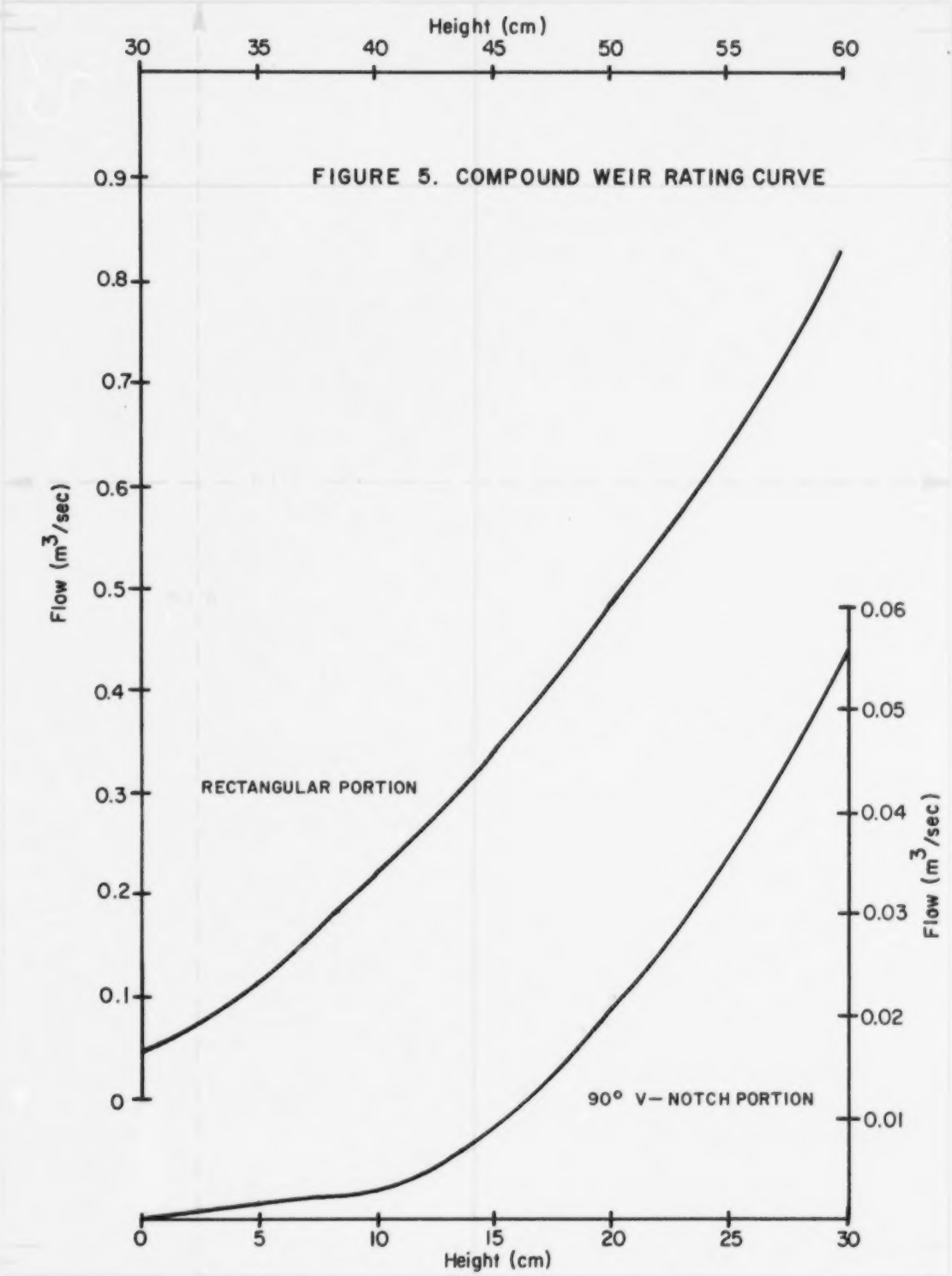


FIGURE 5. COMPOUND WEIR RATING CURVE

Flow Range (in^3/sec)	Winter
0.0 to 0.00283	Q = -0.00028 + 0.00096P + Qp
0.00283 to 0.00566	Q = -0.00067 + 0.00135P + Qp
0.00566 to 0.01133	Q = -0.00169 + 0.00141P + Qp
0.01133 to 0.02265	Q = -0.00492 + 0.00093P + Qp
0.02265 to 0.04531	Q = -0.01098 + 0.00142P + Qp

Where Q = flow in cubic meters per second

P = precipitation in millimeters

Qp = flow on previous day in meters per second

For example, if 10 mm of precipitation were measured on July 1 and the flow for June 30 was measured as 0.004 m^3/sec., the flow for July 1 would be estimated as:

$$Q = -0.0006 + 0.00069\ (10) + 0.004$$

$$Q = 0.0103\ m^3/sec$$

An examination of the above set of equations reveals that the y-intercept is negative and increases in magnitude with flow. The value of the slope (the coefficient of P) increases with flow in the summer. During dry periods (low flow) a combination of evapotranspiration and soil absorption retains more of the precipitation before a significant increase in flow occurs.

In the winter this trend is not observed possibly due to frozen ground and snow cover affecting infiltration and runoff rates.

Monitoring Equipment

Monitoring equipment mounted at the monitoring station included:

1. A water stage recorder with on and off controls,
2. Air temperature meter
3. Water temperature meter
4. pH meter
5. Conductivity meter
6. Turbidity meter
7. A tipping bucket rain gage
8. A strip chart recorder
9. A digital cassette data logger, and
10. Power inverter.

The water level recorder was modified to produce an electric signal proportional to the water level. This signal was recorded on the strip chart and was also used to turn the monitoring equipment off during periods of zero flow, or to change the frequency of monitoring from once every hour to once every five minutes during rains and high flow periods.

The air and water temperature meters consisted of two thermocouples connected to identical temperature meters providing instantaneous temperatures and output to the strip chart recorder. The air temperature thermocouple is mounted on the north side of the "I" beam supporting the rain gage. The water temperature thermocouple is located near the discharge of the water quality monitoring manifold inside the monitoring station.

The manifold is a series of plastic pipe fixtures which allowed the individual probes for the turbidity, pH and conductivity meters to be held within the stream of water which was pumped by a diaphragm pump from immediately below the V of the weir. The manifold also contained an ultrasonic cleaner for the pH and conductivity probes and a motorized brush for cleaning the windows on the turbidity meter. The brush was activated by a timer to clean the windows periodically.

The turbidity, pH and conductivity probes were connected to individual meters which provided instantaneous displays of the respective values and signals which were recorded on the strip chart recorder.

The rain gage was a tipping bucket type with an electronic totalizer which would indicate up to 254 mm (10 in.) before resetting. The totalizer also provided a signal to the strip chart recorder. The rain gage was mounted at the top of a 5 meter "I" beam directly over the monitoring station.

The digital cassette data logger was initially planned to be the primary data recording unit for the Rhoades Branch monitoring station with a twelve-channel strip chart recorder as a back-up unit. Information on the cassettes were to have been translated to a nine channel tape compatible with an IBM 1130 computer and flat-bed plotter. With this method, plots of parameters versus time or other parameters could be developed. Best fit equations could also be developed. Several tapes were recorded before they were shipped out to be translated. Very little useable data was generated from the tapes. Frequently entire lines of data would appear as negative values and one side of one tape, although recorded, provided no data. This was attributed to extraneous signals generated at the same time as input signals were recorded. Later, tapes were recorded on one side only with no significant improvement in output quality. A malfunction in the data logger prevented further use of this system and no attempt was made to obtain repairs because of the high cost and low expected benefits. The twelve-channel strip chart recorder became the prime recording unit.

The monitoring station was a concrete structure built next to and interconnected with the weir. This structure proved very effective. No loss or damage to major equipment from the elements or vandalism was encountered throughout the project.

MINING ACTIVITY

As mentioned earlier, Tackett and Manning Corporation submitted a mining plan for Rhoades Branch to KDNREP in June, 1975, (Figure 6). This plan showed the access and haulroad location and proposed sediment pond locations. No design plans for the ponds were submitted. These ponds were designed by the

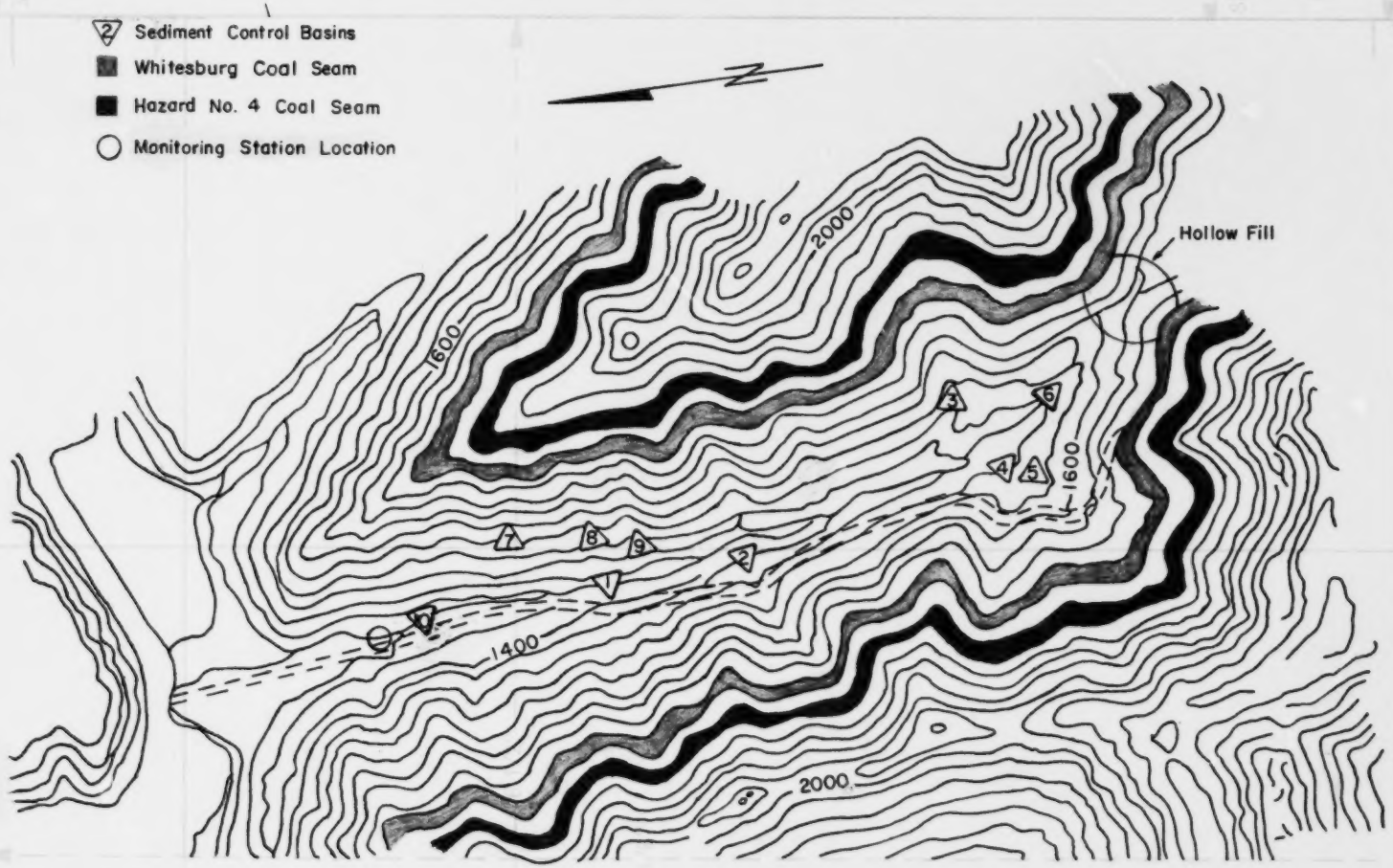


Figure 6. RHOADES BRANCH MINING PLAN

NOTE: This plan was reduced from that submitted to KDNREP by the mining company. The English system of measurement was used. A metric conversion table is included on page viii

bulldozer operator in the field, a common practice at that time in this area. An "as-built" schematic cross section and plan view for these basins is shown in Figure 7. The main stream basin did not have a corrugated metal pipe as the principal spillway.

The first area disturbed by mining activities was 7.1 ha for the access and haulroad in August, 1976 (Figure 8, Area 1), at the same time monitoring equipment was being installed at the station. Crossover pipes were placed every 60 meters along the road, beginning about 60 meters upstream from the weir. Flow from a portion of the watershed west of the haulroad and north of the first culvert was diverted away from the weir by the road ditch, reducing the monitored area of the watershed to 91 ha. In February, 1977, mining began on the east side of the watershed at the head of the hollow (Figure 8, Area 2)

The flood of April 4-5, 1977, caused several landslides along the outslope of the haulroad. These slides provided new erosion surfaces on the outslope where good vegetation cover had previously been established.

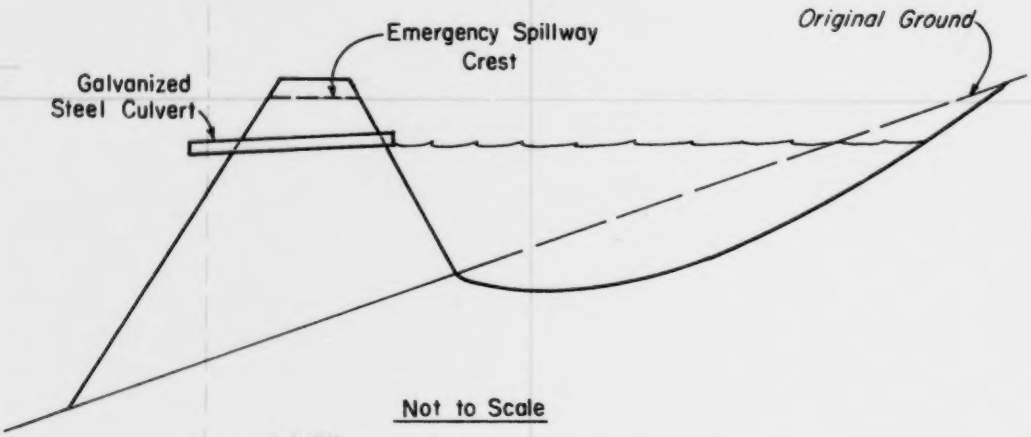
On April 25, 1977, mining began in Area 4 (Figure 8) to the west of the head-of-hollow fill bringing the total disturbed area to 11.0 ha. Area 5 (Figure 8) was begun on May 16, 1977, and Area 6 on June 1, 1977. This is the extent of mining on the west side of the basin. In Areas 5 and 6, the ground cover was removed and the coal was faced, but no coal was removed. Total disturbed area by July 1, 1977, was 13.1 ha. Mining first occured in Area 7 (Figure 8) on September 1, 1977. Area 8 (Figure 8) was the final area disturbed before all mining was stopped by the UMWA coal strike.

Areas 7 and 8, like Areas 5 and 6, had all ground cover removed and the coal was faced but not removed. Total disturbed area by mining in the basin was 15.1 ha or about seventeen (17%) percent of the area monitored by the weir.

In late October, 1977, the mining company built a large rock barrier dam across Rhoades Branch, about 52 meters (170 feet) upstream of the weir, Pond 10. Pond 1, the main stream basin was filled with sediment and not cleaned. This rock barrier dam was probably intended to replace the filled pond.

No further mining activity occurred in the basin after October, 1977. All slopes were hydroseeded in August, 1978. Pond 6, immediately below the head-of-hollow fill was filled with sediment by March, 1979.

The amount of coal faced and not extracted indicates that mining at some future time is very likely.



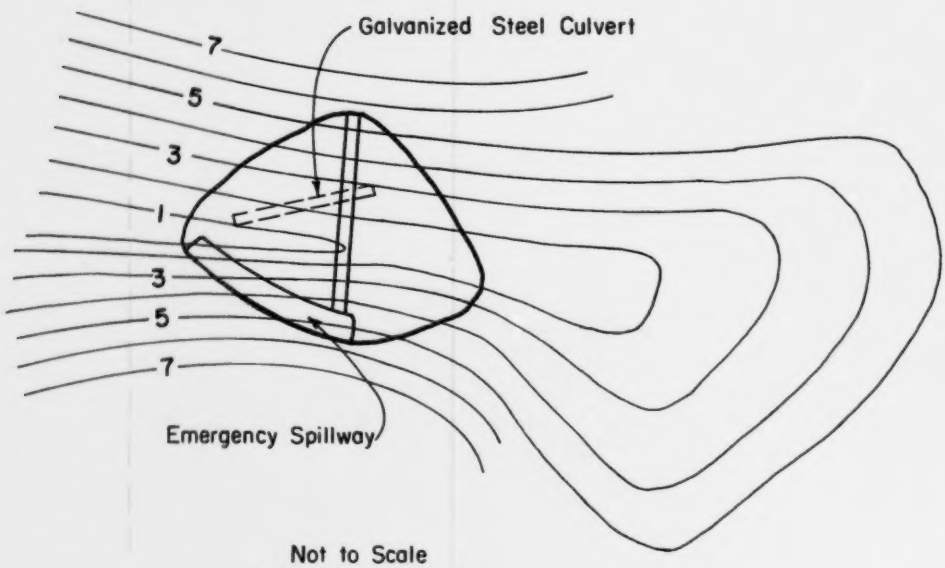


Figure 7. As-built Cross section & Schematic Plan View of a Typical Debris Basin.

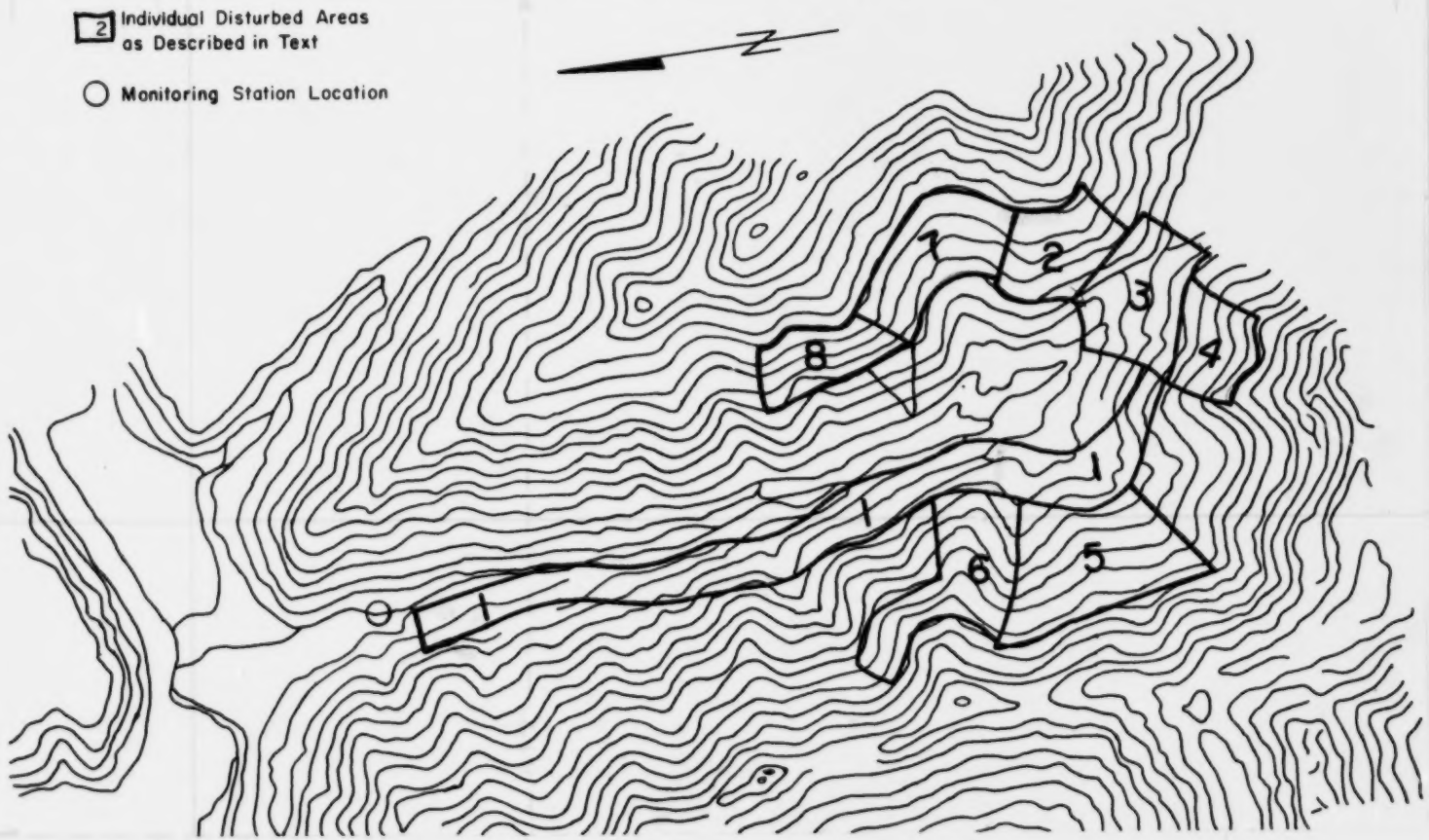


Figure 8. Generalized Location of Disturbed Areas.

SECTION 5

MONITORING RESULTS

SEDIMENT

Calculations

Because of slope steepness and the type of erosion occurring on the strip mine outslopes, the Musgrave Equation for sheet erosion on steep slopes was used instead of the Universal Soil Loss Equation.[9] The Musgrave Equation is:

$$E = I\ R\ (S)^{1.35}\ (L)^{0.35}\ (P_{30})^{1.75}\ \text{(English Units)}$$

Where E = on site soil loss in acre-inches per year
(1 acre-inch = 102.8 m^3)

	Universal Soil Loss Equation Equivalent
I = Erodibility factor	K
R = Cover factor	C,P
S = Percent of slope	S
L = Length of slope	L

P_{30} = 30 min, 2 year precipitation event

Soils in the study area were classified by the local Soil Conservation Service as Gilpin, Jefferson and Shelocta Series. Grain size curves previously reported [2] showed the soils are silty loams with rock fragments. The erodibility factor (I) for silty loams is 0.28. Cover factor (R) ranges from 1.0 for bare earth to 0.001 for climax forest. Values were selected for the condition of the land for the period calculated. Percent slope (S) and Length of Slope (L) were taken from available mapping and field observations. The 30 minute, two year precipitation event was 28 mm for the study site.

Using this equation gives the onsite sediment loss for one year per acre. To determine the estimated yields the following information was used:

1. Size of area
2. Sediment delivery ratio
3. Erosion index based on actual precipitation,
4. Time of year and condition of land.

The following calculation is an example of how the sediment yield from each section of the basin was determined. Adjustments were made periodically to correct for changes in cover and precipitation.

Example: What is the sediment yield from one acre of unvegetated outslope, averaging 200 feet long at a 2H:1V slope from August 1, 1977 to December 1, 1977.

$$E = (0.28)\ (1)\ (.50)^{1.35}\ (200)^{0.35}\ (1.1)^{1.75}$$

E = 0.829 Acre-inches/year or 85.2 cubic meters/acre/year.

To determine the sediment yield for a portion of the year, the distribution of rainfall erosion indices for eastern Kentucky were used[10]. This index is the average percent of sediment erosion per month based on average rainfall and climate. Erosion indices for August through November in east Kentucky are 0.2, 0.08, 0.04 and 0.04. Average precipitation for the same months are 98mm, 76mm, 52mm and 66mm. Actual precipitation for August through November, 1977 was 151mm, 57mm, 159mm and 141mm. Monthly erosion factors were calculated with the following equation and added to obtain the sediment yield for the period August 1 through December 1, 1977.

$$E_m = C(1 + (A-B)/B)$$

Where E_m = monthly erosion factor
C = monthly erosion index
A = measured actual monthly precipitation
B = average monthly precipitation

For the example:

$$E\ \text{August} = 0.2\ (1 + (151-98)/98)$$
$$= 0.308$$

Erosion factors for September, October and November, 1977 are 0.060, 0.122 and 0.085 respectively.

Total sediment for the time period was 85.2 x 0.575 = 49.0 cu. meters.

Results

The Musgrave Equation as described above provided the following table (Table 1) of calculated sediment yields delivered to the stream during the study period from each of the mining areas shown on Figure 8.

TABLE 1. CALCULATED SEDIMENT YIELD FROM DIFFERENT AREAS OF RHOADES BRANCH

Area	Sediment Yield Tonnes
Area #1 (Haulroad, includes Area 4)	359
Area #2	41
Area #3 (Head of Hollow Fill)	1946
Area #5	42
Area #6	9
Area #7	128
Area #8	170
Slides from storm of 4/5/77	79
Slide which formed about 9/1/78	95
Undisturbed areas	291
Logging (estimated)	200
TOTAL	3,360

These calculations compared quite well with the measurements made during the study period as shown in Table 2.

TABLE 2. MEASURED SEDIMENT ACCUMULATION

	Tonnes
Basin #6	1383
Basin #3	101
Basin #1	687
Basin #10	324
Sediment removed from weir pool	48
Suspended sediment flowing by the weir	1160
TOTAL	3,703

The sediment accumulated in the basins was determined by surveying the surface areas of the basin and determining the depth to natural soil while collecting samples of the deposited material. The total volume of sediment in the basin was then calculated from this information.

The total sediment flowing past the weir was determined by adding the daily sediment loads. The daily sediment load was determined from a turbidity versus suspended sediment relationship developed through data obtained from the grab samples. The turbidity values were plotted against the suspended sediment values for all of the grab samples taken from Rhoades Branch. A linear regression was then performed on this data producing the

equation:

$$SS = 0.589\ T^{1.193}$$

Where SS = The suspended sediment concentration in Mg/L

T = The turbidity in nephelometric turbidity units (NTU)

This equation was then used to convert the turbidity values gathered through continuous monitoring to Mg/L suspended solids and ultimately to tonnes of suspended sediment.

The turbidity meter installed in the monitoring station could measure turbidity values up to 2400 NTU. During periods of high flow, the turbidity would occasionally be greater than 2400 NTU. Under these conditions a suspended sediment concentration equivalent to 2400 NTU (6349 Mg/L) was used as a conservative estimate of the actual sediment load.

Due to the limited amount of mining actually completed, as compared to the original plans, six of the basins never received runoff from the mining area. Basins #4 and #5 did not receive runoff because runoff was diverted by the haulroad drainage.

Debris Basin Efficiencies

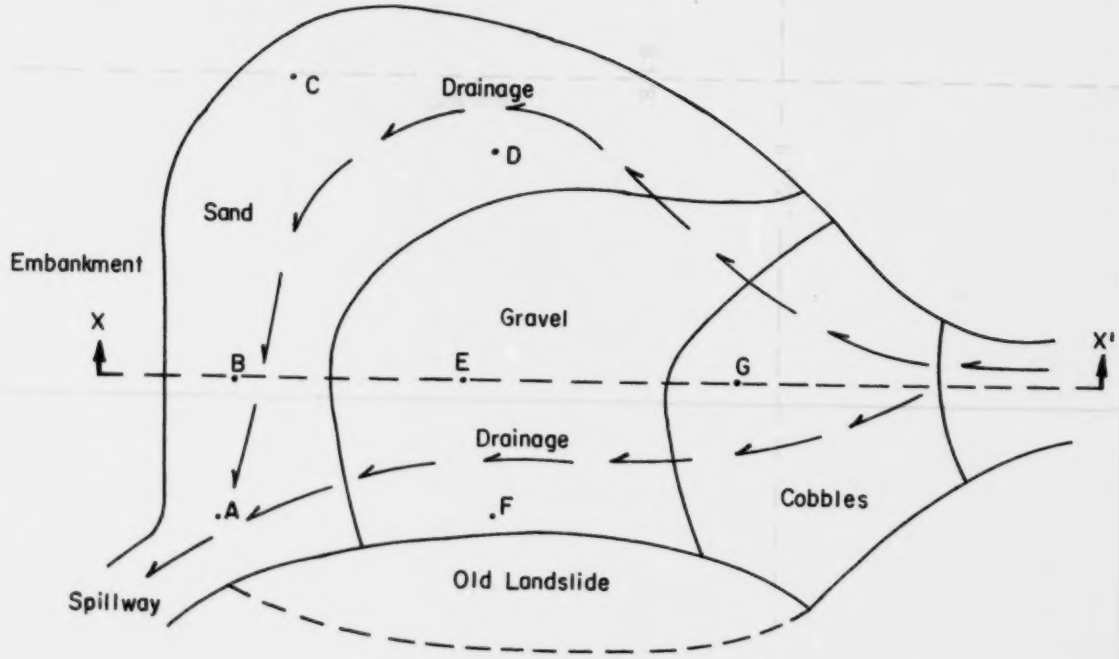
The efficiency of the sediment ponds was calculated as percent Eff. = 100 A/B where A is the total amount of sediment deposited in the basin and B is the total amount of sediment entering the pond. The efficiency of a sediment pond is affected by many factors including: wind and wave action, inlet and outlet design, flow pattern through the pond, pond configuration, surface area of the pond, velocity and volume.

As mentioned earlier, there was no apparent attempt made to design the ponds to increase their efficiency, or to meet the Kentucky Department for Natural Resources and Environmental Protection (KDNREP) requirement of 0.2 acre feet per acre of disturbed area. All of basins were defficient in this respect.

Basin #1 was located on the main stream of Rhoades Branch approximately 250 meters upstream of the monitoring station. It received the runoff from 89 ha of the basin. Its original volume was 612 m^3 which was reduced to 504 m^3 by a slide on the outslope of the haulroad during the April 4-5, 1977 flood. Basin #1 was extremely undersized providing only 7% of the storage area required under the KDNREP regulations. This small size resulted in its complete filling with sediment in only 15 months. In spite of its small size, Basin #1 operated at a 69% efficiency during its life, trapping 687 of the calculated 990 tons of sediment which entered the pond.

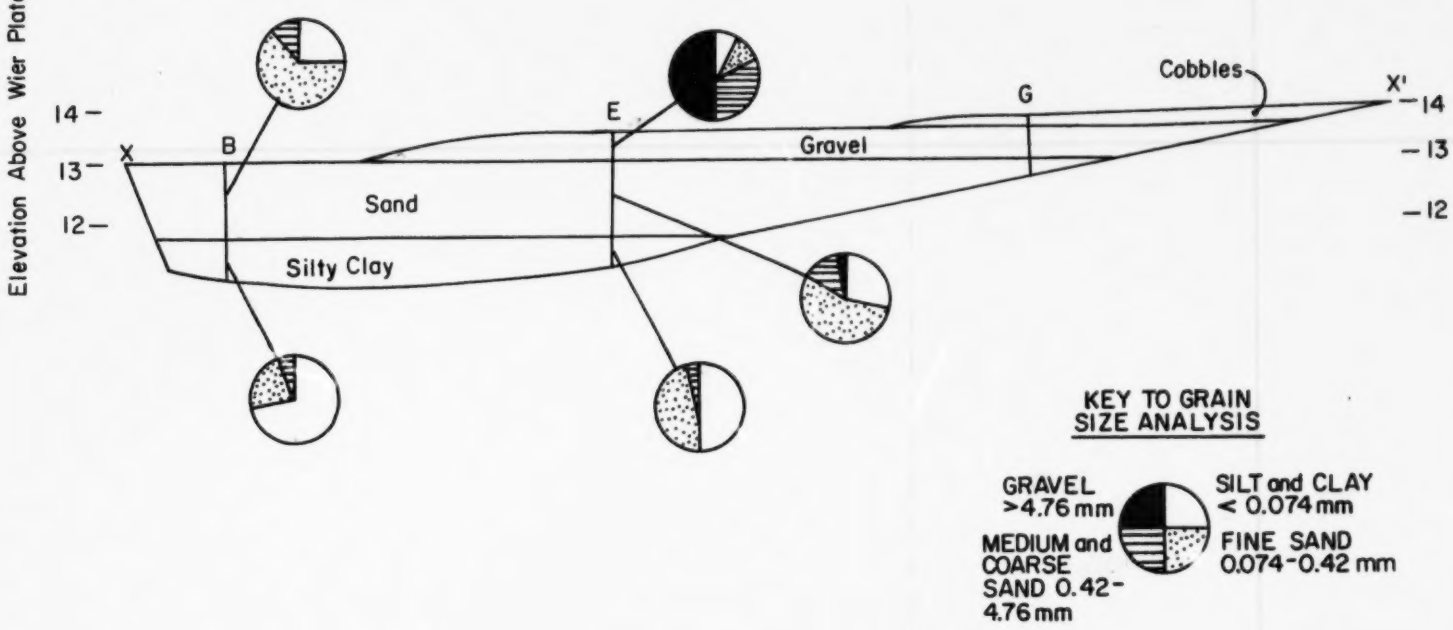
Figures 9 and 10 show the distribution of the deposited sediment in basin #1 by size and also shows the sediment sampling locations. The results of the analyses of these samples are presented on the grain size curves in

Figure 9. BASIN N°1 SEDIMENT ACCUMULATION DISTRIBUTION
PLAN VIEW



1 Cm = 3 M
A-G Sediment Sample Locations

Figure 10. BASIN N°I SEDIMENT ACCUMULATION DISTRIBUTION
PROFILE VIEW
Scale: H 1 Cm = 2 M
V 1 Cm = 1 M



Appendix C. An examination of the profile view of Basin #1 shows that silt and clays were deposited in the downstream portion of the basin for a short period of time. As the basin filled and the detention time decreased, the silt and clay sized particles washed through the basin with only sand and gravel sized particles filling the remainder of the basin.

Basin #3 is a typical basin built in a side hollow. It drained a 1.4 ha area disturbed by mining. When the principal spillway pipe became separated at a joint due to settling of the dam and plugged, the total volume of the basin increased to 74 m^3 with the emergency spillway serving as the only spillway. The emergency spillway is located very close to the entrance channel of basin #3, short circuiting the major portion of the basin and reducing the overall efficiency of the basin to 79%.

Three sediment samples were analyzed for Basin #3. Sample #3C was collected between the inflow area and the emergency spillway and is approximately half sand and gravel. Samples 3A and 3B were collected in the area which has been short circuited and are mostly silt and clay.

Basin #6 is located immediately below the toe of the head of hollow fill. The upstream end of the basin receives runoff directly from the lower portion of the fill while runoff from the upper portion of the fill is diverted and enters basin #6 near its left abutment. The principal spillway is located near the right abutment which provides a very uniform flow pattern through the basin. Because of this design and its larger size, basin #6 had a high sediment removal efficiency (71%) but was still smaller than the regulated size. It also became filled by the end of the study period.

Figures 11 and 12 show a plan and profile view of the sediment accumulated in basin #6. The profile view is similar to that for basin #1 with a larger amount of silt and clay probably due to the larger volume to drainage area ratio. The plan view shows the effect of two sources of sediment entering the basin.

Basin #10 was constructed as a replacement for Basin #1 in November, 1977. It is a rock barrier 5m (15 feet) high with no impervious core. During periods of high flow sediment is deposited behind the barrier, but is washed through the barrier during periods of lower flows. Three hundred and twenty-four tonnes of sediment accumulated behind this barrier by the end of the study period for a 29% efficiency. Figure 13 shows the cumulative sediment removed from the weir pool with time. The abrupt change in amount of sediment removed beginning in the Spring of 1978 shows the filling of Basin #1 and the lower efficiency of the rock barrier, Basin #10. Table 3 provides pertinent characteristics of the four basins which received sediment from disturbed areas.

Figure 11 BASIN #6 (NEAR HEAD-OF-HOLLOW FILL) SEDIMENT ACCUMULATION DISTRIBUTION

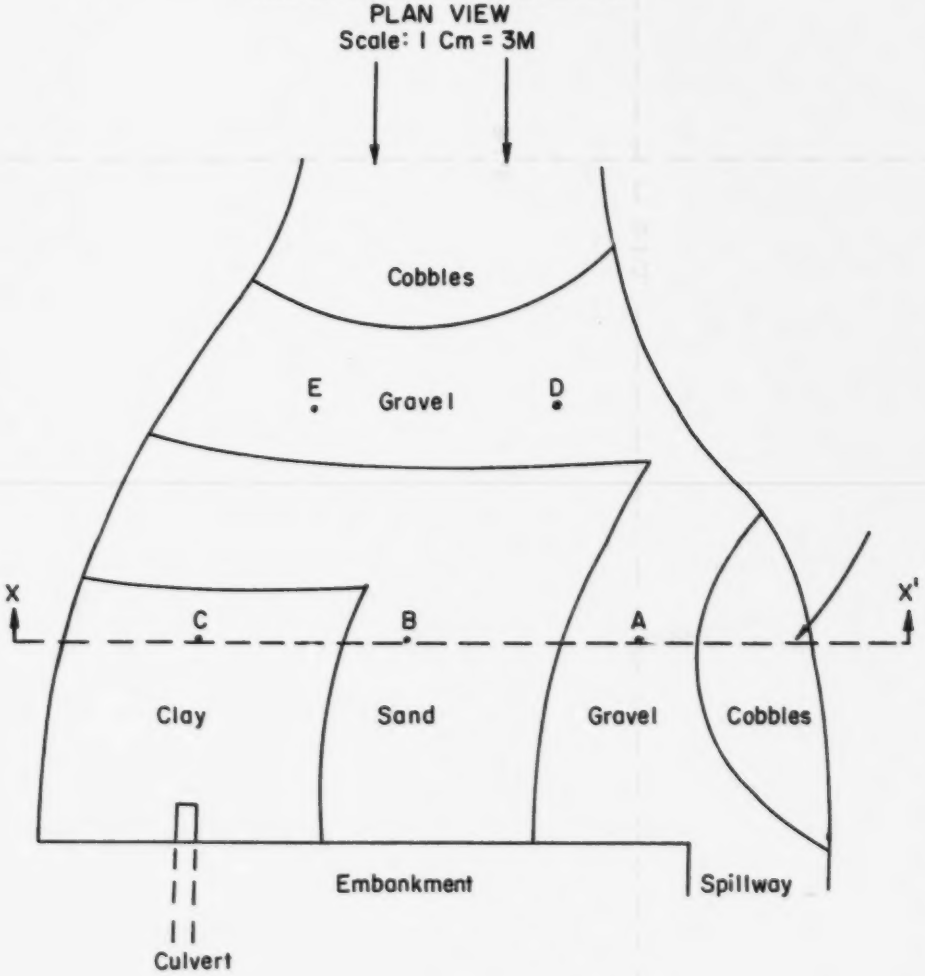
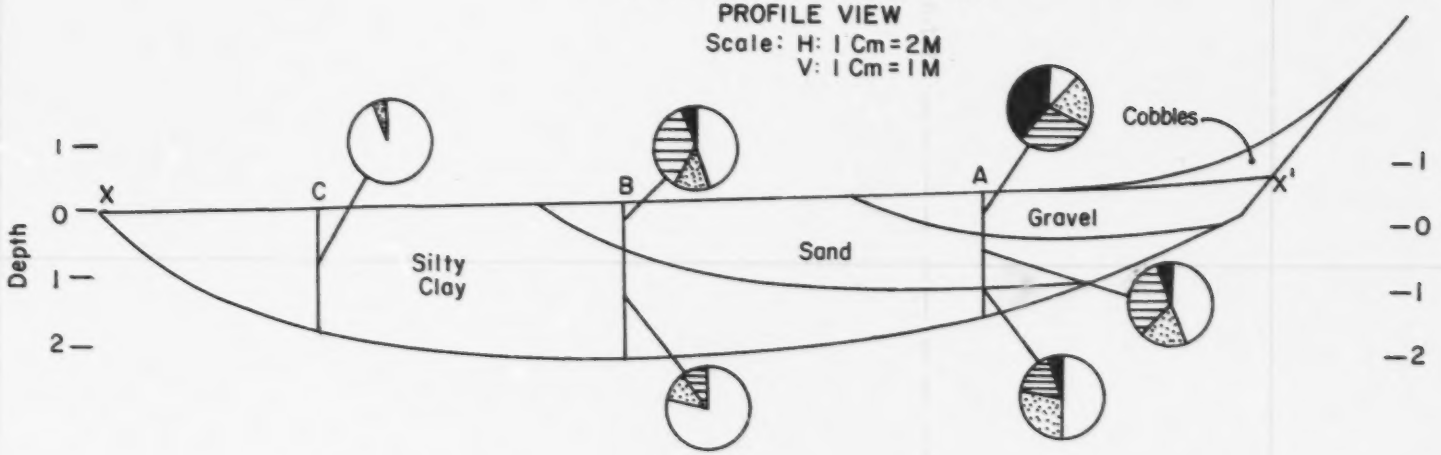


Figure 12 BASIN #6 (NEAR HEAD-OF-HOLLOW FILL) SEDIMENT ACCUMULATION DISTRIBUTION

PROFILE VIEW

Scale: H: 1 Cm = 2M
V: 1 Cm = 1 M



KEY TO GRAIN SIZE ANALYSIS

GRAVEL >4.76 mm

MEDIUM and COARSE SAND 0.42-4.76 mm

SILT and CLAY < 0.074 mm

FINE SAND 0.074 - 0.42 mm

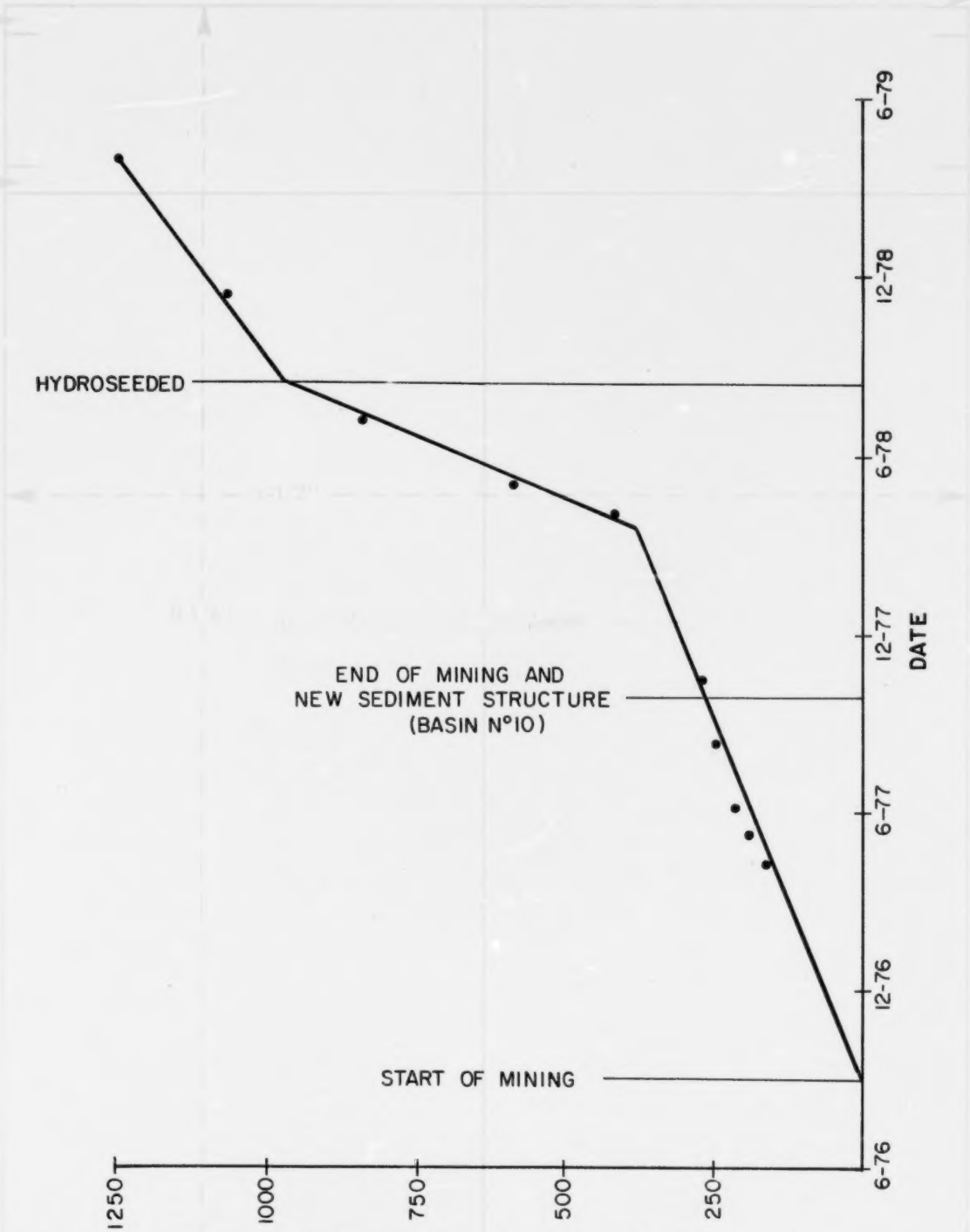


Figure 13. TOTAL SEDIMENT REMOVED FROM WEIR POOL (CUBIC FEET)

TABLE 3. PERTINENT CHARACTERISTICS OF THE FOUR BASINS WHICH RECEIVED SEDIMENT FROM DISTURBED AREAS

Basin	Calculated Sediment Inflow (tonnes)	Sediment Deposited (tonnes)	Efficiency	Basin Volume (m^3)	Contributing Disturbed Area (ha)	Volume to Area Ratio* (M^3/ha)
1	990	687	69%	504	14.6	34.5
3	128	101	79%	74	1.4	53.0
6	1946	1383	71%	1015	4.0	257.0
10	1120	324	29%	5341	15.1	354.0

*$610m^3$/ha required by KDNREP

Basin #1 was the last pond of the pond system from August, 1976 until November, 1977. During this time period the calculated sediment inflow was 1831 tonnes and the total sediment deposited was 1529 tonnes for a combined efficiency of 84%. The combined basin volume was $1593M^3$ with a contributing disturbed area of 14.6 ha and a volume to area ratio of $109M^3$/ha.

Basin #10 became the last pond of the pond system from November, 1977 until the end of the project. During this time frame the sediment inflow was 1763 tonnes and the total sediment deposited was 967 tonnes for a system efficiency of 55%. Combined basin volumes were $5341M^3$ with a contributing disturbed area of 15.1 ha and a volume to area ratio of $426M^3$/ha. The significant decrease in efficiency in spite of a larger volume to area ratio is attributed to the rock barrier structure of Basin #10.

WATER QUALITY

Records

Figures 14 through 17 are condensed forms of the strip chart records for precipitation events which occurred during each of the four seasons. Figure 14, for the period October 2-3, 1977, is a typical event occurring before Basin #10 was built. Previous to this time, most storms showed two peaks in Turbidity. The first peak would occur due to runoff from the lower portion of the haulroad and the second peak would occur several hours later from the flow increase in the main stream.

After the construction of Basin #10 the initial peak was reduced because this basin delayed most of the runoff from the haulroad.

Records of many storms during the study period are recorded on the strip charts. The data contained is too extensive to be included in the appendices except as the daily ranges or averages which are presented in Appendix A.

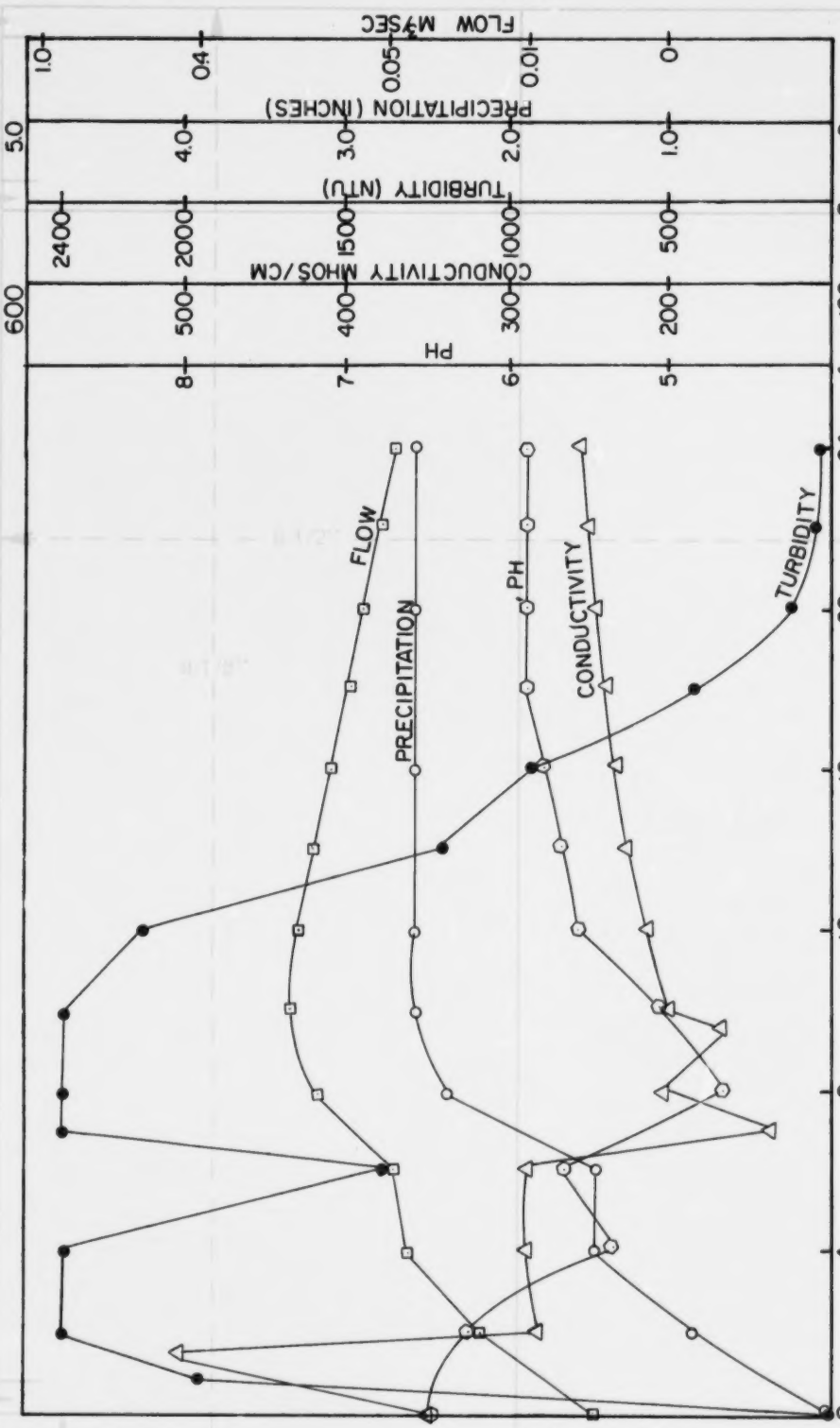


Figure 14. Reproduction of the strip chart record for October 2-3, 1977, rainfall.

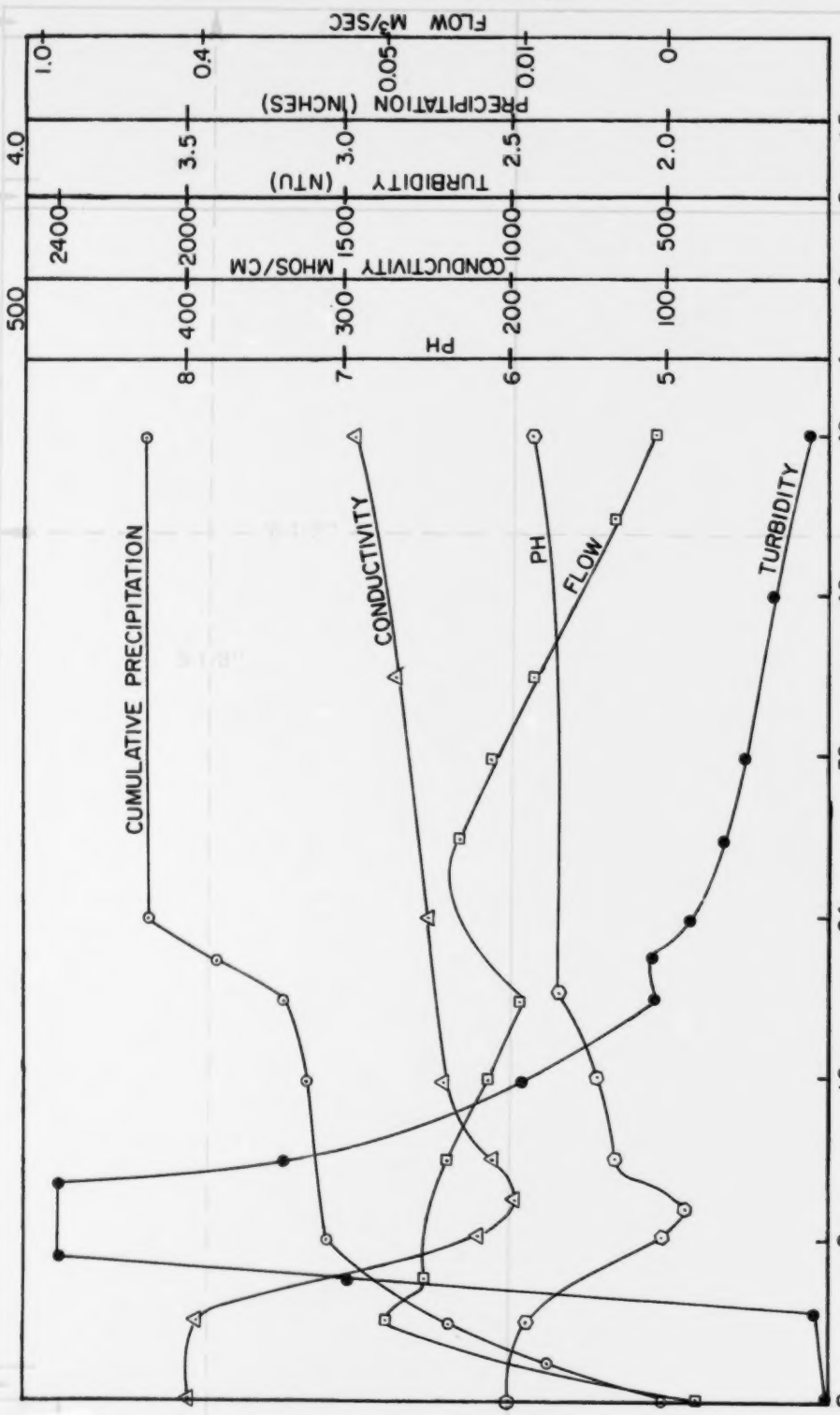


Figure 15. Reproduction of the strip chart record for December 3-5, 1978, rainfall.

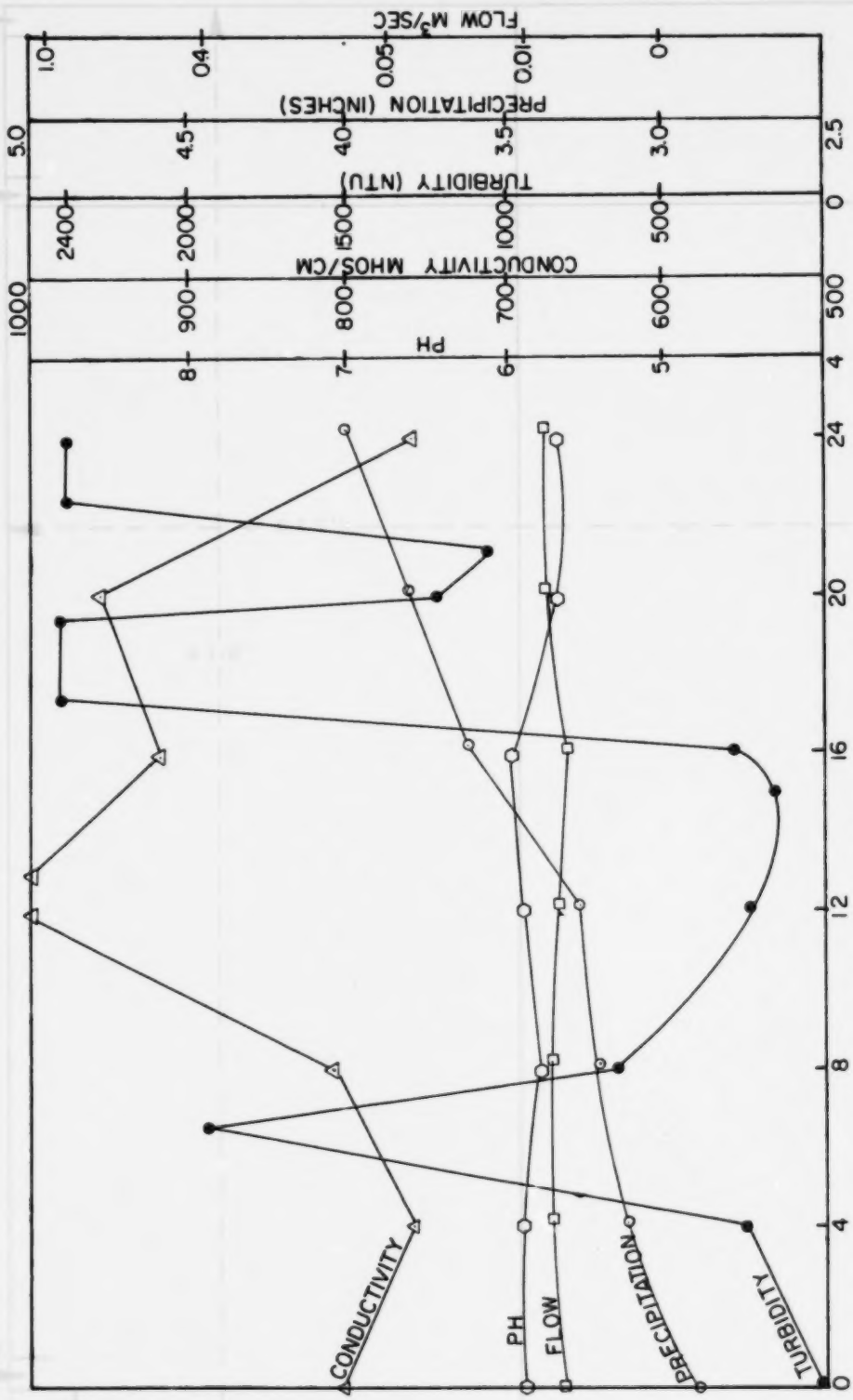


Figure 16. Reproduction of the strip chart record for April 4, 1978, rainfall.

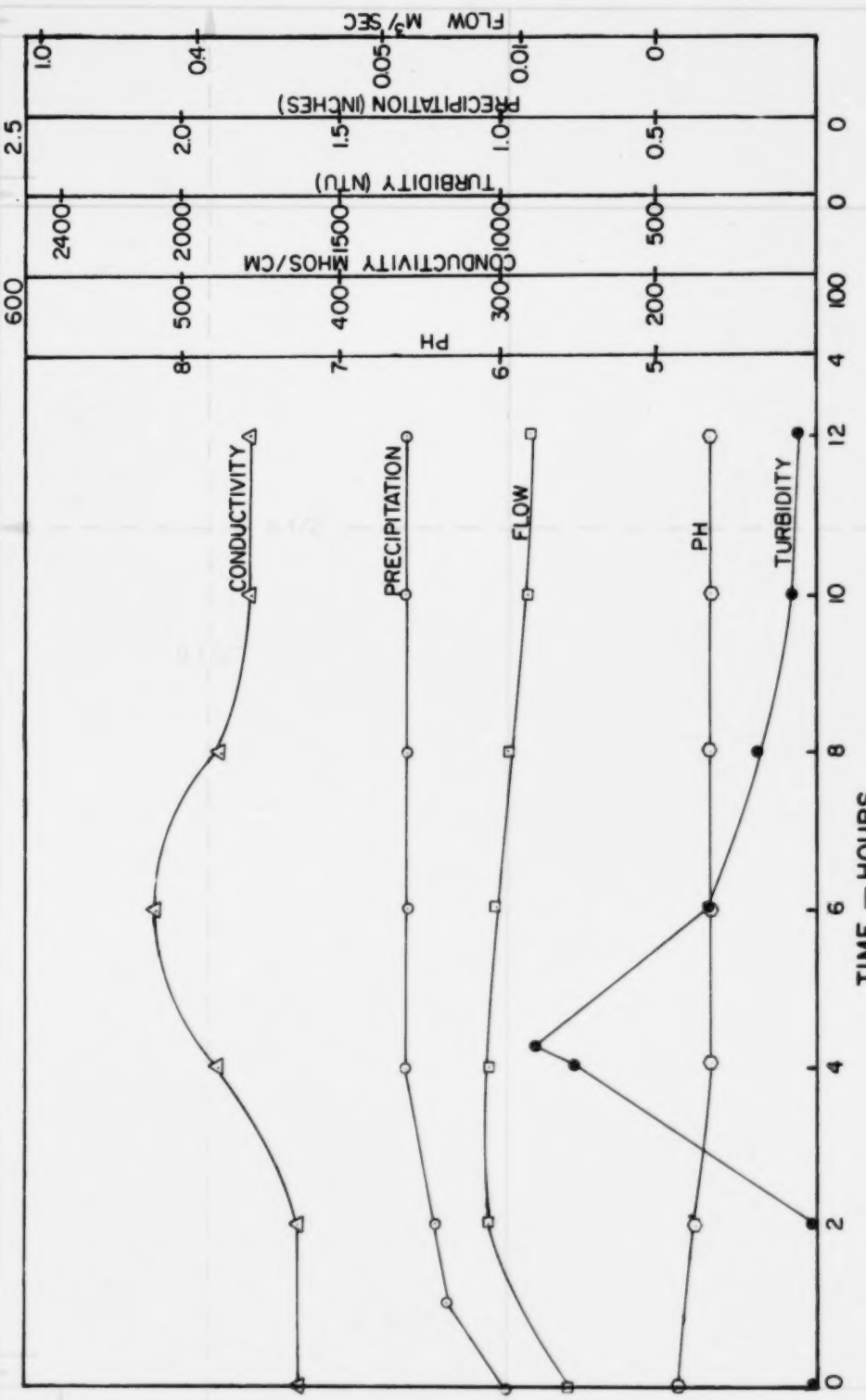


Figure 17. Reproduction of the strip chart record for July 25, 1978, rainfall.

Results

Appendix B contains the water quality analyses for all grab samples collected during the study. These samples were taken at three locations. Samples identified as Rhoades Branch Upstream were taken about 3m (10 feet) upstream from the tailwaters of Basin #1. Samples identified as Rhoades Branch Downstream were taken at the V-notch weir. Samples identified as Dick Branch were taken about 10 m (33 feet) above the confluence of Dick Branch with Rockhouse Creek.

These analyses show that a significant increase in sulfates, hardness and conductivity occurred in Rhoades Branch by the end of March, 1977, about seven months after initial disturbance (building the haulroad and starting the head-of-hollow fill) and one month after active mining in the watershed began. Time of year, relatively low flows and frozen ground may have caused this lag-time.

Insignificant increases for these same parameters were found in Dick Branch at about the same time. These increases may have been caused by residents' activities in the Dick Branch watershed. The Dick Branch watershed had higher values of sulfate, hardness and conductivity before mining began in Rhoades Branch. Table 4 shows the range, mean and standard deviation for these parameters for both watersheds.

TABLE 4. SULFATE, HARDNESS AND CONDUCTIVITY RANGE, MEAN AND STANDARD DEVIATION VALUES FOR RHOADES BRANCH AND DICK BRANCH GRAB SAMPLES

	Rhoades Branch			Dick Branch		
Parameter	Range	Mean	Std. Dev.	Range	Mean	Std. Dev.
Sulfate						
1/27/75 to 3/8/77	12-47	29	10	13-58	32	11
5/11/77 to 3/29/79	70-191	135	37	10-62	38	15
Hardness						
1/27/75 to 3/9/77	20-86	43	17	22-104	47	25
5/11/77 to 3/29/79	90-232	153	35	29-96	59	24
Conductivity						
1/29/75 to 3/9/77	47-410	119	67	51-430	160	106
5/11/77 to 3/29/79	165-520	354	88	100-365	216	90

REFERENCES

1. L. Robert Kimball Consulting Engineers. Prefeasibility Study Demonstration of Debris Basins for Control of Surface Mine Sedimentation in Steep Slope Terrain. Lexington, Kentucky, 1972. 87pp.

2. L. Robert Kimball Consulting Engineers. Feasibility Study Demonstration of Debris Basin Effectiveness in Sediment Control. Lexington, Kentucky, 1975. 56pp.

3. Mills, Thomas R. and Michael L. Clar. Erosion and Sediment Control, Surface Mining in the Eastern U.S., planning. EPA-625-3-76-006, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1976. 102pp.

4. Kathuria, D.Vir, Michael A. Nawrocki, and Burton C. Becker. Effectiveness of Surface Mine Sedimentation Ponds. EPA-600/2-76-117, U.S. Environmental Protection Agency, Cincinnati, Ohio, 1976. 101pp.

5. White, James R. and William T. Plass. Sediment Control Using Modified Mining and Regrading Systems and Sediment Control Structures In: Papers Presented Before the Second Research and Applied Technology Symposium on Mined Land Reclamation. National Coal Association, 1974. pp117-123.

6. Department for Natural Resources and Environmental Protection, Commonwealth of Kentucky. A Manual on Compliance with Kentucky's Surface Mining and Reclamation Laws and Regulations. Part III. Silt Handbook., 60pp.

7. Rice, Charles L. Geologic Map of the Mayking Quadrangle, Letcher and Knott Counties, Kentucky. U.S.G.S. Map GQ-1309, U.S. Geological Survey, Reston, Virginia, 1976.

8. United States Department of the Interior, Bureau of Reclamation. Water Measurement Manual. U.S. Government Printing Office, Washington, 1975. 327pp.

9. U.S. Environmental Protection Agency. Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants. EPA-430/9-73-014, Cincinnati, Ohio, 1973. 261pp.

10. U.S. Department of Argiculture, Soil Conservation Service. Predicting Soil Loss Using the Universal Soil Loss Equation. Lexington, Kentucky, 1978. 150pp.

BIBLIOGRAPHY

1. Collier, C.R., R.J. Pickering, and J.J. Musser. Influences of Strip Mining on the Hydraulic Environment of Parts of Beaver Creek Basin, Kentucky, 1955-66, Geological Survey Professional Paper 427-C, U.S. Government Printing Office, Washington, 1970. 80pp.

2. Curtis Willie R. Sediment Yield from Strip-Mined Watersheds in Eastern Kentucky In: Papers Presented Before the Second Research and Applied Technology Symposium on Mined Land Reclamation. National Coal Association, 1974.

3. Department for Natural Resources and Environmental Protection, Commonwealth of Kentucky. Engineer's Handbook on Strip Mining in Eastern Kentucky.

4. Elam, A.B. et.al. Precipitation Probabilities for Kentucky. University of Kentucky, College of Agriculture, Department of Agricultural Engineering. Lexington. 55pp.

5. Hill, Ronald D. Sedimentation Ponds - A Critical Review. U.S. Environmental Protection Agency, Cincinnati, Ohio, 20pp.

6. Jent, C.H. Jr., F.F. Bell, and M.E. Springer. Predicting Soil Losses in Tennessee Under Different Management Systems. University of Tennessee, Agricultural Experiment Station, 1967. 75pp.

7. Kentucky Department of Natural Resources, Division of Water. Rainfall Frequency values for Kentucky, Engineering Memorandum No. 2, 1971. 37pp.

8. Malcolm, H. Rooney Jr. and Charles Smallwod Jr. Sediment Prediction in the Eastern United States. Journal of the Water Resources Planning and Management Division. November, 1977. pp285-298.

9. McKenzie, Garry D. and Joseph R.J. Studlick. Determination of Spoil-Bank Erosion Rates in Ohio by Using Interbank Sediment Accumulations. Geology Volume 6 p499-502.

10. Rains, Michael T. and Edmond I. Swenson. Erosion Analysis on the New River Basin. SA.A and PF Doraville, Georgia, 1977.

11. Reed, Lloyd A., Sediment Characteristics of Five Streams Near Harrisburg, Pennsylvania, Before Highway Construction, Geological Survey Water-Supply Paper 1798-M, U.S. Government Printing Office, Washington, 1976. 29pp.

12. Reed, Lloyd A. Effectiveness of Sediment-Control Techniques Used During Highway Construction in Central Pennsylvania, Geological Survey Water Supply Paper 2054. U.S. Government Printing Office, Washington, 1978. 57pp.

13. Soil Conservation Society of America. Soil Erosion: Prediction and Control, Special Publication No. 21, Ankeny, Iowa.

14. United States Department of the Interior, Bureau of Reclamation. Water Measurement Manual. U.S. Government Printing Office, Washington, 1975. 327pp.

15. United States Environmental Protection Agency. Methods for Identifying and Evaluating the Nature and Extent of Nonpoint Sources of Pollutants. U.S. Government Printing Office, Washington, D.C., 1973. 261pp.

16. United States Environmental Protection Agency. Effectiveness of Surface Mine Sedimentation Ponds, EPA-600/2-76-117, Cincinnati, Ohio, 1976. 101pp.

17. United States Environmental Protection Agency. Erosion and Sediment Control, Surface Mining in the Eastern U.S. Design. EPA-625/3-76-006, U.S. Government Printing Office, 1976. 136pp.

18. Vanoni, Vito A., Editor. Sedimentation Engineering American Society of Civil Engineers, 1977. 745pp.

19. Wilmoth, Roger C. and James L. Kennedy. Removal of Trace Elements from Acid Mine Drainage. EPA-600/7-79-101. U.S. Environmental Protection Agency, Cincinnati, Ohio, 1979. 77pp.

20. Wilson, Larry W., Noah J. Matthews, and James L. Stump. Underground Coal Mining Methods to Abate Water Pollution: A State of the Art Literature Review. EPA Project No. 14010FKK, 1970. 50pp.

21. Wischmeier, Walter H., and Dwight D. Smith. Predicting Rainfall Erosion Losses -A Guide to Conservation Planning. U.S. Department of Agriculture, Agriculture Handbook No. 537, U.S., Government Printing Office, Washington, D.C., 1978. 58pp.

APPENDIX A

Contained herein are the precipitation, flow, pH, temperature, turbidity and conductivity values for the life of the project.

Flow measurements are taken from the monitoring station records or were calculated as discussed in the text. When water flow measurements were calculated, as dicussed in the text, they are marked with an asterisk in Appendix A. When the precipitation was a weighted average, rather than being measured at the site, it is marked with an asterisk in Appendix A.

Appendix A - DAILY PRECIPITATION AND FLOW VALUES

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
12/08/76	0.0346	1.22	0	0 *
12/09/76	0.0286	1.01	0	0 *
12/10/76	0.0175	0.618	0	0 *
12/11/76	0.0136	0.480	2	0.09 *
12/12/76	0.0142	0.500	9	0.35 *
12/13/76	0.0212	0.750	0	0.02 *
12/14/76	0.0252	0.890	0	0 *
12/15/76	0.0204	0.720	1	0.03 *
12/16/76	0.0176	0.620	2	0.06 *
12/17/76	0.0153	0.540	0	0 *
12/18/76	0.0054	0.190	0	0 *
12/19/76	0.0040	0.140	0	0 *
12/20/76	0.0028	0.100	2	0.10 *
12/21/76	0.0031	0.110	2	0.10 *
12/22/76	0.0020	0.069	0	0 *
12/23/76	0.0009	0.031	0	0 *
12/24/76	0.0008	0.029	0	0 *
12/25/76	0.0007	0.023	0	0.02 *
12/26/76	0.0003	0.010	4	0.15 *
12/27/76	0.0011	0.038	0	0.01 *
12/28/76	0.0011	0.038	0	0.01 *
12/29/76	0.0018	0.062	0	0 *
12/30/76	0.0020	0.072	0	0 *
12/31/76	0.0009	0.031	7	0.28 *
01/01/77	0.0018	0.062	0	0 *
01/02/77	0.0029	0.101	0	0 *
01/03/77	0.0003	0.012	1	0.04 *
01/04/77	0.0004	0.013	0	0 *
01/05/77	0.0011	0.038	5	0.21 *
01/06/77	0.0018	0.065	1	0.04 *
01/07/77	0.0080*	0.281	8	0.33 *
01/08/77	0.0067*	0.238	0	0 *
01/09/77	0.0113*	0.399	2	0.06 *
01/10/77	0.0169*	0.597	5	0.19 *
01/11/77	0.0134*	0.472	0	0 *
01/12/77	0.0098*	0.347	0	0 *
01/13/77	0.0086*	0.304	0	0 *
01/14/77	0.0217*	0.768	10	0.40 *
01/15/77	0.0227*	0.802	5	0.19 *
01/16/77	0.0223*	0.786	3	0.13 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
01/17/77	0.0187*	0.661	0	0 *
01/18/77	0.0152*	0.536	0	0 *
01/19/77	0.0123*	0.436	1	0.03 *
01/20/77	0.0098*	0.345	1	0.04 *
01/21/77	0.0103*	0.365	1	0.05 *
01/22/77	0.0095*	0.335	0	0.01 *
01/23/77	0.0083*	0.292	0	0 *
01/24/77	0.0153*	0.541	6	0.23 *
01/25/77	0.0135*	0.475	2	0.07 *
01/26/77	0.0142*	0.501	5	0.18 *
01/27/77	0.0111*	0.392	0	0.02 *
01/28/77	0.0099*	0.349	0	0 *
01/29/77	0.0087*	0.306	0	0 *
01/30/77	0.0074*	0.263	0	0 *
01/31/77	0.0062*	0.220	0	0 *
02/01/77	0.0050*	0.177	0	0 *
02/02/77	0.0045*	0.160	0	0 *
02/03/77	0.0040*	0.143	0	0 *
02/04/77	0.0036*	0.126	0	0 *
02/05/77	0.0038*	0.133	3	0.11 *
02/06/77	0.0033*	0.116	0	0 *
02/07/77	0.0028*	0.099	0	0 *
02/08/77	0.0026*	0.092	0	0 *
02/09/77	0.0024*	0.085	0	0 *
02/10/77	0.0022*	0.078	0	0 *
02/11/77	0.0020*	0.071	0	0 *
02/12/77	0.0023*	0.081	0	0.02 *
02/13/77	0.0053*	0.187	3	0.13 *
02/14/77	0.0048*	0.170	0	0 *
02/15/77	0.0056*	0.197	5	0.20 *
02/16/77	0.0052*	0.184	0	0.02 *
02/17/77	0.0049*	0.174	1	0.03 *
02/18/77	0.0059*	0.210	6	0.24 *
02/19/77	0.0047*	0.167	0	0 *
02/20/77	0.0055*	0.193	5	0.20 *
02/21/77	0.0067*	0.235	7	0.27 *
02/22/77	0.0054*	0.192	0	0 *
02/23/77	0.0050*	0.175	0	0 *
02/24/77	0.0054*	0.191	4	0.15 *
02/25/77	0.0049*	0.174	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
02/26/77	0.0044*	0.157	0	0 *
02/27/77	0.0046*	0.162	3	0.10 *
02/28/77	0.0041*	0.145	0	0 *
03/01/77	0.0039*	0.137	1	0.04 *
03/02/77	0.0036*	0.127	1	0.03 *
03/03/77	0.0044*	0.156	5	0.21 *
03/04/77	0.0045*	0.160	2	0.10 *
03/05/77	0.0040*	0.143	0	0 *
03/06/77	0.0036*	0.126	0	0 *
03/07/77	0.0031*	0.109	0	0 *
03/08/77	0.0026*	0.092	0	0 *
03/09/77	0.0039	0.136	0	0 *
03/10/77	0.0052	0.184	0	0 *
03/11/77	0.0042	0.147	0	0 *
03/12/77	0.0056	0.197	0	0.01 *
03/13/77	0.0126	0.445	23	0.91 *
03/14/77	0.0120	0.424	0	0 *
03/15/77	0.0103	0.362	0	0 *
03/16/77	0.0084	0.298	0	0 *
03/17/77	0.0072	0.256	0	0 *
03/18/77	0.0168	0.592	0	0.23 *
03/19/77	0.0198	0.700	0	0.36 *
03/20/77	0.0190	0.672	12	0.49 *
03/21/77	0.0182	0.644	0	0 *
03/22/77	0.0157	0.553	5	0.20 *
03/23/77	0.0103	0.362	0	0 *
03/24/77	0.0077	0.272	0	0 *
03/25/77	0.0072	0.256	0	0 *
03/26/77	0.0064	0.226	0	0 *
03/27/77	0.0064	0.226	0	0 *
03/28/77	0.0045	0.159	0	0 *
03/29/77	0.0068	0.240	0	0 *
03/30/77	0.0072	0.256	5	0.20 *
03/31/77	0.0045	0.159	0	0 *
04/01/77	0.0039	0.136	0	0 *
04/02/77	0.0058	0.204	0	0 *
04/03/77	0.0134	0.472	22	0.88 *
04/04/77	0.513	18.1	67	2.65 *
04/05/77	0.261	9.20	45	1.76 *
04/06/77	0.0586	2.07	6	0.25 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
04/07/77	0.0405	1.43	0	0 *
04/08/77	0.0334	1.18	0	0 *
04/09/77	0.0281	0.991	0	0 *
04/10/77	0.0207	0.730	0	0 *
04/11/77	0.0136	0.480	0	0 *
04/12/77	0.0097	0.343	0	0 *
04/13/77	0.0092	0.324	0	0 *
04/14/77	0.0072	0.256	0	0 *
04/15/77	0.0072	0.256	0	0 *
04/16/77	0.0068	0.240	0	0 *
04/17/77	0.0060	0.211	0	0 *
04/18/77	0.0052	0.185	0	0 *
04/19/77	0.0045	0.159	0	0 *
04/20/77	0.0039	0.136	0	0 *
04/21/77	0.0033	0.115	0	0 *
04/22/77	0.0030	0.106	1	0.04 *
04/23/77	0.0047	0.165	9	0.35 *
04/24/77	0.0077	0.273	8	0.31 *
04/25/77	0.0045	0.159	3	0.13 *
04/26/77	0.0035	0.125	0	0 *
04/27/77	0.0033	0.115	0	0.01 *
04/28/77	0.0077	0.273	2	0.07 *
04/29/77	0.0077	0.273	21	0.83 *
04/30/77	0.0064	0.226	0	0 *
05/01/77	0.0094	0.331	0	0 *
05/02/77	0.0113	0.400	3	0.13 *
05/03/77	0.0133	0.468	0	0.02 *
05/04/77	0.0114	0.403	0	0.02 *
05/05/77	0.0133	0.468	6	0.22 *
05/06/77	0.0097	0.343	2	0.06 *
05/07/77	0.0092	0.324	1	0.04 *
05/08/77	0.0072	0.256	2	0.06 *
05/09/77	0.0072	0.256	0	0 *
05/10/77	0.0040	0.142	0	0 *
05/11/77	0.0034	0.121	0	0 *
05/12/77	0.0025	0.088	0	0 *
05/13/77	0.0025	0.088	0	0 *
05/14/77	0.0020	0.072	0	0 *
05/15/77	0.0018	0.065	0	0 *
05/16/77	0.0018*	0.065	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
05/17/77	0.0016*	0.058	0	0 *
05/18/77	0.0014*	0.051	0	0 *
05/19/77	0.0012*	0.044	0	0 *
05/20/77	0.0052*	0.185	4	0.17 *
05/21/77	0.0048*	0.168	0	0 *
05/22/77	0.0170*	0.599	8	0.32 *
05/23/77	0.0195*	0.687	6	0.23 *
05/24/77	0.0174*	0.613	2	0.08 *
05/25/77	0.0134*	0.474	0	0.02 *
05/26/77	0.0095*	0.336	0	0.02 *
05/27/77	0.0080*	0.282	0	0 *
05/28/77	0.0089*	0.313	23	0.09 *
05/29/77	0.0073*	0.259	0	0 *
05/30/77	0.0058*	0.205	0	0 *
05/31/77	0.0043*	0.151	0	0 *
06/01/77	0.0037*	0.130	0	0 *
06/02/77	0.0031*	0.109	0	0 *
06/03/77	0.0025*	0.088	0	0 *
06/04/77	0.0023*	0.080	0	0 *
06/05/77	0.0020*	0.072	0	0 *
06/06/77	0.0087*	0.308	12	0.47 *
06/07/77	0.0072*	0.254	0	0 *
06/08/77	0.0057*	0.200	0	0 *
06/09/77	0.0242*	0.856	19	0.75 *
06/10/77	0.0163*	0.577	0	0 *
06/11/77	0.0118*	0.417	0	0 *
06/12/77	0.0076*	0.268	0	0.01 *
06/13/77	0.0061*	0.214	0	0 *
06/14/77	0.0045*	0.160	0	0 *
06/15/77	0.0122*	0.431	5	0.18 *
06/16/77	0.0077*	0.271	0	0 *
06/17/77	0.0131*	0.463	7	0.26 *
06/18/77	0.0089	0.314	0	0.01 *
06/19/77	0.0027	0.094	11	0.43 *
06/20/77	0.0025	0.088	5	0.21 *
06/21/77	0.0026	0.094	10	0.38 *
06/22/77	0.0303	1.07	35	1.39 *
06/23/77	0.0241	0.850	8	0.32 *
06/24/77	0.0175	0.617	8	0.30 *
06/25/77	0.0144	0.510	0	0.01 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
06/26/77	0.0146	0.516	8	0.31 *
06/27/77	0.0442	1.56	15	0.59 *
06/28/77	0.0294*	1.04	3	0.11 *
06/29/77	0.0207	0.730	1	0.05 *
06/30/77	0.0161*	0.570	0	0 *
07/01/77	0.0242	0.856	20	0.79 *
07/02/77	0.0179	0.631	9	0.36 *
07/03/77	0.0114	0.403	0	0 *
07/04/77	0.0092	0.325	0	0 *
07/05/77	0.0075	0.265	0	0 *
07/06/77	0.0042	0.150	0	0 *
07/07/77	0.0034	0.120	0	0 *
07/08/77	0.0025	0.089	0	0 *
07/09/77	0.0103	0.363	5	0.18 *
07/10/77	0.0139	0.492	14	0.53 *
07/11/77	0.0126	0.446	0	0 *
07/12/77	0.0092	0.325	0	0 *
07/13/77	0.0066	0.233	0	0 *
07/14/77	0.0050	0.178	0	0 *
07/15/77	0.0039	0.136	0	0 *
07/16/77	0.0033	0.116	0	0 *
07/17/77	0.0027	0.097	0	0 *
07/18/77	0.0025	0.088	2	0.09 *
07/19/77	0.0025	0.088	1	0.03 *
07/20/77	0.0020	0.072	0	0 *
07/21/77	0.0018	0.065	0	0 *
07/22/77	0.0016	0.058	3	0.11 *
07/23/77	0.0013	0.046	0	0 *
07/24/77	0.0013	0.058	0	0 *
07/25/77	0.0018	0.062	10	0.41 *
07/26/77	0.0014	0.049	0	0 *
07/27/77	0.0011	0.038	0	0 *
07/28/77	0.0003	0.010	0	0 *
07/29/77	0.0014	0.049	0	0 *
07/30/77	0.0018	0.062	0	0 *
07/31/77	0.0020	0.072	0	0 *
08/01/77	0.0018	0.065	0	0.02 *
08/02/77	0.0013	0.046	0	0 *
08/03/77	0.0013	0.046	0	0 *
08/04/77	0.0012	0.041	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
08/05/77	0.0012	0.043	5	0.21 *
08/06/77	0.0016	0.058	15	0.60 *
08/07/77	0.0016	0.058	4	0.14 *
08/08/77	0.0018	0.065	0	0.01 *
08/09/77	0.0073	0.257	11	0.43 *
08/10/77	0.0229	0.807	27	1.07 *
08/11/77	0.0223	0.788	7	0.26 *
08/12/77	0.0283	0.998	8	0.31 *
08/13/77	0.0291	1.028	30	1.17 *
08/14/77	0.0256	0.905	15	0.58 *
08/15/77	0.0199	0.701	4	0.14 *
08/16/77	0.0191	0.673	0	0.01 *
08/17/77	0.0160	0.565	3	0.12 *
08/18/77	0.0108	0.383	4	0.14 *
08/19/77	0.0084	0.298	0	0 *
08/20/77	0.0073	0.257	0	0 *
08/21/77	0.0058	0.204	0	0 *
08/22/77	0.0043	0.153	0	0 *
08/23/77	0.0036	0.126	0	0 *
08/24/77	0.0037	0.131	9	0.34 *
08/25/77	0.0036	0.126	6	0.25 *
08/26/77	0.0030	0.106	0	0 *
08/27/77	0.0025	0.088	0	0 *
08/28/77	0.0020	0.072	0	0 *
08/29/77	0.0018	0.065	2	0.08 *
08/30/77	0.0016	0.058	0	0 *
08/31/77	0.0022	0.076	2	0.08 *
09/01/77	0.0045	0.159	0	0 *
09/02/77	0.0047	0.165	2	0.08 *
09/03/77	0.0045	0.159	0	0 *
09/04/77	0.0040	0.142	0	0 *
09/05/77	0.0039	0.136	0	0 *
09/06/77	0.0033*	0.115	0	0 *
09/07/77	0.0077*	0.273	3	0.11 *
09/08/77	0.0062*	0.219	0	0 *
09/09/77	0.0047*	0.165	0	0 *
09/10/77	0.0041*	0.144	0	0 *
09/11/77	0.0035*	0.123	0	0 *
09/12/77	0.0029*	0.102	0	0 *
09/13/77	0.0187	0.659	5	0.21 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)	
09/14/77	0.0224	0.792	12	0.48	*
09/15/77	0.0187	0.659	2	0.09	*
09/16/77	0.0153	0.540	10	0.38	*
09/17/77	0.0136	0.480	0	0	*
09/18/77	0.0106	0.373	0	0	*
09/19/77	0.0092	0.325	0	0	*
09/20/77	0.0075	0.265	0	0	*
09/21/77	0.0042	0.148	0	0	
09/22/77	0.0022	0.076	0	0	
09/23/77	0.0018	0.065	0	0	
09/24/77	0.0018	0.065	3	0.13	
09/25/77	0.0016	0.058	0	0	
09/26/77	0.0016	0.058	0	0	
09/27/77	0.0016	0.058	0	0	
09/28/77	0.0016	0.058	0	0	
09/29/77	0.0020	0.069	8	0.30	
09/30/77	0.0031	0.111	11	0.45	
10/01/77	0.0026	0.092	0	0	
10/02/77	0.0024	0.084	0	0	
10/03/77	0.0779	2.75	36	2.60	
10/04/77	0.0260	0.918	0	0	
10/05/77	0.0198	0.699	0	0	
10/06/77	0.0309	1.09	10	0.40	
10/07/77	0.0215	0.761	0	0	
10/08/77	0.0592	2.09	56	2.20	
10/09/77	0.0345	1.22	5	0.18	
10/10/77	0.0411	1.45	8	0.30	
10/11/77	0.0276	0.974	0	0	
10/12/77	0.0292	1.03	9	0.35	
10/13/77	0.0213*	0.751	0	0	*
10/14/77	0.0177*	0.626	0	0	*
10/15/77	0.0142*	0.501	0	0	*
10/16/77	0.0261*	0.921	16	0.65	*
10/17/77	0.0182*	0.642	0	0	*
10/18/77	0.0146*	0.517	0	0	*
10/19/77	0.0092	0.325	0	0	
10/20/77	0.0084	0.298	0	0	
10/21/77	0.0068	0.241	0	0	
10/22/77	0.0062	0.219	0	0	
10/23/77	0.0052	0.184	0	0	

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
10/24/77	0.0050	0.178	0	0
10/25/77	0.0089	0.315	15	0.58
10/26/77	0.0124	0.438	2	0.06
10/27/77	0.0106	0.373	2	0.08
10/28/77	0.0100	0.353	0	0.01
10/29/77	0.0092	0.325	0	0
10/30/77	0.0084	0.298	1	0.03
10/31/77	0.0073	0.257	0	0.01
11/01/77	0.0068	0.241	0	0
11/02/77	0.0064	0.226	0	0
11/03/77	0.0062	0.219	0	0
11/04/77	0.0064	0.226	0	0.01
11/05/77	0.0060	0.212	1	0.03
11/06/77	0.0923	3.26	30	1.17
11/07/77	0.0631*	2.23	19	0.74 *
11/08/77	0.0479*	1.69	11	0.44 *
11/09/77	0.0402*	1.42	3	0.01 *
11/10/77	0.0411*	1.45	6	0.24 *
11/11/77	0.0331*	1.17	0	0 *
11/12/77	0.0253*	0.894	0	0 *
11/13/77	0.0174*	0.615	0	0 *
11/14/77	0.0139*	0.490	0	0 *
11/15/77	0.0103*	0.365	0	0 *
11/16/77	0.0091*	0.322	0	0 *
11/17/77	0.0119*	0.419	3	0.11 *
11/18/77	0.0083*	0.294	0	0 *
11/19/77	0.0071*	0.251	0	0 *
11/20/77	0.0059*	0.208	0	0 *
11/21/77	0.0093*	0.330	33	0.13 *
1.592/77	0.0450*	1.59	26	1.03 *
11/23/77	0.0405*	1.43	2	0.09 *
11/24/77	0.0385*	1.36	4	0.16 *
11/25/77	0.0306*	1.08	0	0 *
11/26/77	0.0309*	1.09	6	0.23 *
11/27/77	0.0317*	1.12	6	0.24 *
11/28/77	0.0368*	1.30	9	0.36 *
11/29/77	0.0456*	1.61	12	0.46 *
11/30/77	0.0411*	1.45	2	0.09 *
12/01/77	0.0331*	1.17	0	0 *
12/02/77	0.0253*	0.892	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON't

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
12/03/77	0.0174*	0.613	0	0 *
12/04/77	0.0140*	0.496	0	0.01 *
12/05/77	0.0419*	1.48	34	1.32 *
12/06/77	0.0419*	1.48	6	0.22 *
12/07/77	0.0399*	1.41	4	0.16 *
12/08/77	0.0320*	1.13	0	0 *
12/09/77	0.0311*	1.10	5	0.20 *
12/10/77	0.0234*	0.825	0	0 *
12/11/77	0.0155*	0.546	0	0 *
12/12/77	0.0119*	0.421	0	0 *
12/13/77	0.0084*	0.296	0	0 *
12/14/77	0.0108*	0.380	2	0.10 *
12/15/77	0.0117*	0.413	2	0.06 *
12/16/77	0.0082*	0.288	0	0 *
12/17/77	0.0069*	0.245	0	0 *
12/18/77	0.0136*	0.482	6	0.22 *
12/19/77	0.0101*	0.357	0	0 *
12/20/77	0.0089*	0.314	0	0 *
12/21/77	0.0077*	0.271	0	0 *
12/22/77	0.0065*	0.228	0	0 *
12/23/77	0.0052*	0.185	0	0 *
12/24/77	0.0048*	0.168	0	0 *
12/25/77	0.0061*	0.214	7	0.29 *
12/26/77	0.0048*	0.171	0	0 *
12/27/77	0.0044*	0.154	0	0 *
12/28/77	0.0039*	0.137	0	0 *
12/29/77	0.0034*	0.120	0	0 *
12/30/77	0.0032*	0.112	1	0.04 *
12/31/77	0.0027*	0.095	0	0 *
01/01/78	0.0030*	0.105	0	0.02 *
01/02/78	0.0025*	0.088	0	0 *
01/03/78	0.0023*	0.081	0	0 *
01/04/78	0.0021*	0.074	0	0 *
01/05/78	0.0024*	0.084	0	0.02 *
01/06/78	0.0083*	0.294	6	0.25 *
01/07/78	0.0071*	0.251	0	0 *
01/08/78	0.0224*	0.792	12	0.46 *
01/09/78	0.0343*	1.21	16	0.65 *
01/10/78	0.0264*	0.933	0	0 *
01/11/78	0.0185*	0.654	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
01/12/78	0.0150*	0.529	0	0 *
01/13/78	0.0126*	0.446	1	0.05 *
01/14/78	0.0191*	0.673	11	0.42 *
01/15/78	0.0179*	0.631	2	0.10 *
01/16/78	0.0179*	0.632	4	0.15 *
01/17/78	0.0246*	0.868	11	0.43 *
01/18/78	0.0212*	0.749	4	0.16 *
01/19/78	0.0213*	0.753	2	0.10 *
01/20/78	0.0411*	1.45	25	0.98 *
01/21/78	0.0334*	1.18	0	0.01 *
01/22/78	0.0256*	0.904	0	0 *
01/23/78	0.0177*	0.625	0	0 *
01/24/78	0.0217*	0.768	8	0.32 *
01/25/78	0.0182*	0.643	0	0 *
01/26/78	0.0147*	0.518	0	0 *
01/27/78	0.0111*	0.393	0	0 *
01/28/78	0.0099*	0.350	0	0 *
01/29/78	0.0087*	0.307	0	0 *
01/30/78	0.0075*	0.264	0	0 *
01/31/78	0.0063*	0.221	0	0 *
02/01/78	0.0050*	0.178	0	0 *
02/02/78	0.0064*	0.227	8	0.30 *
02/03/78	0.0052*	0.184	0	0 *
02/04/78	0.0047*	0.167	0	0 *
02/05/78	0.0044*	0.156	1	0.03 *
02/06/78	0.0039*	0.139	0	0 *
02/07/78	0.0036*	0.127	0	0.02 *
02/08/78	0.0031*	0.110	0	0 *
02/09/78	0.0026*	0.093	0	0 *
02/10/78	0.0024*	0.086	0	0 *
02/11/78	0.0022*	0.079	0	0 *
02/12/78	0.0020*	0.072	0	0 *
02/13/78	0.0048*	0.169	3	0.12 *
02/14/78	0.0059*	0.207	6	0.25 *
02/15/78	0.0046*	0.164	0	0 *
02/16/78	0.0054*	0.190	5	0.20 *
02/17/78	0.0049*	0.173	0	0 *
02/18/78	0.0049*	0.174	2	0.08 *
02/19/78	0.0044*	0.157	0	0 *
02/20/78	0.0040*	0.140	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
02/21/78	0.0041*	0.145	2	0.10 *
02/22/78	0.0036*	0.128	0	0 *
02/23/78	0.0031*	0.111	0	0 *
02/24/78	0.0028*	0.098	0	0.02 *
02/25/78	0.0026*	0.091	0	0 *
02/26/78	0.0024*	0.084	0	0 *
02/27/78	0.0022*	0.077	0	0 *
02/28/78	0.0059*	0.209	4	0.16 *
03/01/78	0.0133*	0.471	6	0.24 *
03/02/78	0.0110*	0.388	1	0.05 *
03/03/78	0.0227*	0.801	9	0.36 *
03/04/78	0.0170*	0.599	2	0.06 *
03/05/78	0.0134*	0.474	0	0 *
03/06/78	0.0099*	0.349	0	0 *
03/07/78	0.0087*	0.306	0	0 *
03/08/78	0.0157*	0.555	6	0.23 *
03/09/78	0.0165*	0.581	5	0.18 *
03/10/78	0.0129*	0.456	0	0 *
03/11/78	0.0094*	0.331	0	0 *
03/12/78	0.0153*	0.542	5	0.20 *
03/13/78	0.0118*	0.417	0	0 *
03/14/78	0.0225*	0.795	15	0.60 *
03/15/78	0.0197*	0.695	1	0.03 *
03/16/78	0.0216*	0.762	6	0.23 *
03/17/78	0.0183*	0.646	0	0.01 *
03/18/78	0.0148*	0.521	0	0 *
03/19/78	0.0112*	0.396	0	0 *
03/20/78	0.0100*	0.353	0	0 *
03/21/78	0.0113*	0.399	2	0.07 *
03/22/78	0.0137*	0.483	2	0.10 *
03/23/78	0.0101*	0.358	0	0 *
03/24/78	0.0089*	0.315	0	0 *
03/25/78	0.0203*	0.716	9	0.35 *
03/26/78	0.0234*	0.825	7	0.28 *
03/27/78	0.0238*	0.841	6	0.23 *
03/28/78	0.0159*	0.562	0	0 *
03/29/78	0.0124*	0.437	0	0 *
03/30/78	0.0160	0.565	0	0 *
03/31/78	0.0183	0.645	0	0 *
04/01/78	0.0139	0.492	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)	
04/02/78	0.0139	0.492	0	0	*
04/03/78	0.0147	0.520	0	0	*
04/04/78	0.0143	0.504	0	0	*
04/05/78	0.0146	0.516	5	0.20	
04/06/78	0.0092	0.325	0	0	
04/07/78	0.0087	0.307	0	0	
04/08/78	0.0082	0.290	0	0	
04/09/78	0.0077	0.273	0	0	
04/10/78	0.0073	0.257	0	0	
04/11/78	0.0058	0.204	0	0	
04/12/78	0.0047	0.165	0	0	
04/13/78	0.0043	0.153	0	0	
04/14/78	0.0039	0.136	0	0	
04/15/78	0.0034	0.121	0	0	
04/16/78	0.0031	0.111	0	0	
04/17/78	0.0033	0.116	18	0.30	
04/18/78	0.0030	0.106	0	0	
04/19/78	0.0030	0.106	2	0.10	
04/20/78	0.0027	0.097	0	0	
04/21/78	0.0025	0.088	0	0	
04/22/78	0.0025	0.088	0	0	
04/23/78	0.0025	0.088	0	0	
04/24/78	0.0026	0.092	11	0.45	
04/25/78	0.0035	0.124	20	0.80	
04/26/78	0.0058	0.204	38	1.50	
04/27/78	0.0365*	1.29	23	0.89	*
04/28/78	0.0286*	1.01	0	0	*
04/29/78	0.0207*	0.732	0	0	*
04/30/78	0.0203*	0.716	3	0.13	*
05/01/78	0.0167*	0.588	1	0.03	*
05/02/78	0.0121*	0.428	0	0	*
05/03/78	0.0076*	0.268	0	0	*
05/04/78	0.0294*	1.04	22	0.87	*
05/05/78	0.0279*	0.986	9	0.34	*
05/06/78	0.0198*	0.700	0	0	*
05/07/78	0.0162*	0.572	1	0.03	*
05/08/78	0.0254*	0.897	11	0.45	*
05/09/78	0.0213*	0.752	7	0.28	*
05/10/78	0.0177*	0.624	1	0.03	*
05/11/78	0.0131*	0.464	0	0	*

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITAION (mm)	PRECIPITATION (Inches)
05/12/78	0.0123*	0.433	3	0.12 *
05/13/78	0.0223*	0.786	14	0.57 *
05/14/78	0.0272*	0.960	8	0.31 *
05/15/78	0.0248*	0.875	2	0.07 *
05/16/78	0.0186*	0.656	0	0.21 *
05/17/78	0.0140*	0.496	0	0 *
05/18/78	0.0095*	0.336	0	0 *
05/19/78	0.0080*	0.282	0	0 *
05/20/78	0.0065*	0.228	0	0 *
05/21/78	0.0055*	0.193	0	0.02 *
05/22/78	0.0049*	0.172	0	0 *
05/23/78	0.0044*	0.157	0	0.01 *
05/24/78	0.0225*	0.793	27	1.05 *
05/25/78	0.0216*	0.762	3	0.12 *
05/26/78	0.0170*	0.602	0	0 *
05/27/78	0.0125*	0.442	0	0 *
05/28/78	0.0080*	0.282	0	0 *
05/29/78	0.0065*	0.228	0	0 *
05/30/78	0.0049*	0.174	0	0 *
05/31/78	0.0103*	0.365	9	0.34 *
06/01/78	0.0088*	0.311	0	0 *
06/02/78	0.0073*	0.257	0	0 *
06/03/78	0.0159*	0.563	10	0.38 *
06/04/78	0.0114*	0.403	0	0 *
06/05/78	0.0069*	0.243	0	0 *
06/06/78	0.0054*	0.189	0	0 *
06/07/78	0.0090*	0.318	6	0.24 *
06/08/78	0.0217*	0.766	14	0.53 *
06/09/78	0.0211*	0.746	3	0.13 *
06/10/78	0.0166*	0.586	0	0 *
06/11/78	0.0121*	0.426	0	0 *
06/12/78	0.0082*	0.288	0	0.02 *
06/13/78	0.0144*	0.508	7	0.29 *
06/14/78	0.0099*	0.348	0	0 *
06/15/78	0.0083*	0.294	0	0 *
06/16/78	0.0068*	0.240	0	0 *
06/17/78	0.0053*	0.186	0	0 *
06/18/78	0.0047*	0.165	0	0 *
06/19/78	0.0046*	0.163	1	0.03 *
06/20/78	0.0083*	0.292	6	0.24 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
06/21/78	0.0121*	0.427	5	0.20 *
06/22/78	0.0091*	0.321	1	0.05 *
06/23/78	0.0076*	0.267	0	0 *
06/24/78	0.0060*	0.213	0	0 *
06/25/78	0.0045*	0.159	0	0 *
06/26/78	0.0119*	0.419	11	0.45 *
06/27/78	0.0073*	0.259	0	0 *
06/28/78	0.0058*	0.205	0	0 *
06/29/78	0.0043*	0.151	0	0 *
06/30/78	0.0037*	0.130	0	0 *
07/01/78	0.0079*	0.278	7	0.27 *
07/02/78	0.0131*	0.461	6	0.25 *
07/03/78	0.0306*	1.08	18	0.72 *
07/04/78	0.0289*	1.02	9	0.34 *
07/05/78	0.0212*	0.750	0	0 *
07/06/78	0.0167*	0.590	0	0 *
07/07/78	0.0122*	0.430	0	0 *
07/08/78	0.0076*	0.270	0	0 *
07/09/78	0.0139*	0.491	7	0.29 *
07/10/78	0.0136*	0.481	4	0.14 *
07/11/78	0.0219*	0.774	11	0.42 *
07/12/78	0.0174*	0.614	0	0 *
07/13/78	0.0247*	0.874	10	0.39 *
07/14/78	0.0219*	0.775	8	0.32 *
07/15/78	0.0180*	0.637	0	0.02 *
07/16/78	0.0214*	0.757	7	0.26 *
07/17/78	0.0169*	0.597	0	0 *
07/18/78	0.0124*	0.437	0	0 *
07/19/78	0.0078*	0.277	0	0 *
07/20/78	0.0063*	0.223	0	0 *
07/21/78	0.0048*	0.169	0	0 *
07/22/78	0.0079*	0.279	5	0.21 *
07/23/78	0.0064*	0.225	0	0 *
07/24/78	0.0207*	0.730	15	0.59 *
07/25/78	0.0382*	1.35	18	0.72 *
07/26/78	0.0462*	1.63	14	0.55 *
07/27/78	0.0348*	1.23	0	0 *
07/28/78	0.0297*	1.05	2	0.10 *
07/29/78	0.0212*	0.750	0	0 *
07/30/78	0.0167*	0.590	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
07/31/78	0.0131*	0.462	1	0.03 *
08/01/78	0.0086*	0.302	0	0 *
08/02/78	0.0070*	0.248	0	0 *
08/03/78	0.0055*	0.194	0	0 *
08/04/78	0.0314*	1.11	38	1.50 *
08/05/78	0.0292*	1.03	8	0.30 *
08/06/78	0.0227*	0.800	5	0.20 *
08/07/78	0.0181*	0.640	0	0 *
08/08/78	0.0227*	0.803	8	0.30 *
08/09/78	0.0182*	0.643	0	0 *
08/10/78	0.0152*	0.537	1	0.05 *
08/11/78	0.0107*	0.377	0	0 *
08/12/78	0.0199*	0.702	10	0.40 *
08/13/78	0.0351*	1.24	16	0.65 *
08/14/78	0.0320*	1.13	0	0 *
08/15/78	0.0255*	0.900	0	0 *
08/16/78	0.0173*	0.610	0	0 *
08/17/78	0.0052	0.184	0	0
08/18/78	0.0045	0.159	0	0
08/19/78	0.0039	0.136	0	0
08/20/78	0.0036	0.126	0	0
08/21/78	0.0036	0.126	0	0
08/22/78	0.0030	0.106	0	0
08/23/78	0.0030	0.106	0	0
08/24/78	0.0023	0.080	0	0
08/25/78	0.0064	0.226	5	0.20
08/26/78	0.0075	0.265	0	0
08/27/78	0.0034	0.121	0	0
08/28/78	0.0030	0.106	0	0
08/29/78	0.0077*	0.273	8	0.30 *
08/30/78	0.0062*	0.219	0	0 *
08/31/78	0.0583*	2.06	51	2.00 *
09/01/78	0.0382*	1.35	0	0 *
09/02/78	0.0340*	1.20	0	0 *
09/03/78	0.0603*	2.13	30	1.20 *
09/04/78	0.0391*	1.38	0	0 *
09/05/78	0.0340*	1.20	0	0 *
09/06/78	0.0283*	1.00	0	0 *
09/07/78	0.0209*	0.730	0	0 *
09/08/78	0.0161*	0.570	0	0 *

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)	
09/09/78	0.0116*	0.410	0	0	*
09/10/78	0.0071*	0.250	0	0	*
09/11/78	0.0149*	0.527	9	0.35	*
09/12/78	0.0104*	0.367	0	0	*
09/13/78	0.0089*	0.313	0	0	*
09/14/78	0.0073*	0.259	0	0	*
09/15/78	0.0125*	0.442	6	0.25	*
09/16/78	0.0080*	0.282	0	0	*
09/17/78	0.0065*	0.228	0	0	*
09/18/78	0.0049*	0.174	0	0	*
09/19/78	0.0043*	0.153	0	0	*
09/20/78	0.0037*	0.132	0	0	*
09/21/78	0.0031*	0.111	0	0	*
09/22/78	0.0025*	0.090	0	0	*
09/23/78	0.0023*	0.082	0	0	*
09/24/78	0.0021*	0.074	0	0	*
09/25/78	0.0019*	0.066	0	0	*
09/26/78	0.0016*	0.058	0	0	*
09/27/78	0.0014*	0.050	0	0	*
09/28/78	0.0012*	0.042	0	0	*
09/29/78	0.0010*	0.034	0	0	*
09/30/78	0.0007*	0.026	0	0	*
10/01/78	0.0042*	0.148	6	0.25	*
10/02/78	0.0036*	0.127	0	0	*
10/03/78	0.0030*	0.106	0	0	*
10/04/78	0.0095*	0.335	10	0.40	*
10/05/78	0.0080*	0.281	0	0	*
10/06/78	0.0064*	0.227	0	0	*
10/07/78	0.0049*	0.173	0	0	*
10/08/78	0.0043*	0.152	0	0	*
10/09/78	0.0037*	0.131	0	0	*
10/10/78	0.0031*	0.110	0	0	*
10/11/78	0.0025*	0.089	0	0	*
10/12/78	0.0023*	0.081	0	0	*
10/13/78	0.0021*	0.073	0	0	*
10/14/78	0.0121*	0.429	18	0.70	*
10/15/78	0.0137*	0.485	5	0.20	*
10/16/78	0.0092*	0.325	0	0	*
10/17/78	0.0077*	0.271	0	0	*
10/18/78	0.0061*	0.217	0	0	*

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
10/19/78	0.0046*	0.163	0	0 *
10/20/78	0.0040*	0.142	0	0 *
10/21/78	0.0034*	0.121	0	0 *
10/22/78	0.0028*	0.100	0	0 *
10/23/78	0.0022*	0.079	0	0 *
10/24/78	0.0020*	0.071	0	0 *
10/25/78	0.0018*	0.063	0	0 *
10/26/78	0.0016*	0.055	0	0 *
10/27/78	0.0057*	0.203	8	0.30 *
10/28/78	0.0042*	0.149	0	0 *
10/29/78	0.0036*	0.128	0	0 *
10/30/78	0.0030*	0.107	0	0 *
10/31/78	0.0029*	0.102	0	0 *
11/01/78	0.0025*	0.090	0	0 *
11/02/78	0.0024*	0.083	0	0 *
11/03/78	0.0022*	0.076	0	0 *
11/04/78	0.0020*	0.069	0	0 *
11/05/78	0.0030*	0.105	1	0.05 *
11/06/78	0.0025*	0.088	0	0 *
11/07/78	0.0023*	0.081	0	0 *
11/08/78	0.0082*	0.291	6	0.25 *
11/09/78	0.0070*	0.248	0	0 *
11/10/78	0.0058*	0.205	0	0 *
11/11/78	0.0046*	0.162	0	0 *
11/12/78	0.0041*	0.145	0	0 *
11/13/78	0.0036*	0.128	0	0 *
11/14/78	0.0031*	0.111	0	0 *
11/15/78	0.0033*	0.116	2	0.10 *
11/16/78	0.0053*	0.187	10	0.40 *
11/17/78	0.0079*	0.279	13	0.50 *
11/18/78	0.0027	0.097	1	0.05
11/19/78	0.0027	0.097	0	0
11/20/78	0.0012	0.041	0	0
11/21/78	0.0015	0.052	0	0
11/22/78	0	0	0	0
11/23/78	0	0.001	5	0.18
11/24/78	0	0	0	0
11/25/78	0	0	0	0
11/26/78	0.0009	0.033	14	0.55
11/27/78	0.0007	0.023	10	0.40

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
11/28/78	0	0	0	0 *
11/29/78	0.0031	0.111	10	0.40 *
11/30/78	0.0002	0.008	0	0 *
12/01/78	0	0.001	0	0 *
12/02/78	0	0	0	0 *
12/03/78	0.0026	0.093	15	0.60 *
12/04/78	0.0278	0.980	46	1.80 *
12/05/78	0.0120	0.423	8	0.30 *
12/06/78	0.0014	0.049	2	0.10 *
12/07/78	0.0016	0.055	13	0.50 *
12/08/78	0.0169	0.597	28	1.10 *
12/09/78	0.0566	2.00	33	1.30 *
12/10/78	0.0377*	1.33	0	0 *
12/11/78	0.0297*	1.05	0	0 *
12/12/78	0.0218*	0.771	0	0 *
12/13/78	0.0183*	0.646	0	0 *
12/14/78	0.0148*	0.521	0	0 *
12/15/78	0.0112*	0.396	0	0 *
12/16/78	0.0100*	0.353	0	0 *
12/17/78	0.0088*	0.310	0	0 *
12/18/78	0.0076*	0.267	0	0 *
12/19/78	0.0063*	0.224	0	0 *
12/20/78	0.0123*	0.435	5	0.20 *
12/21/78	0.0266*	0.938	19	0.75 *
12/22/78	0.0187*	0.659	0	0 *
12/23/78	0.0151*	0.534	0	0 *
12/24/78	0.0116*	0.409	0	0 *
12/25/78	0.0171*	0.603	10	0.38 *
12/26/78	0.0135*	0.478	0	0 *
12/27/78	0.0100*	0.353	0	0 *
12/28/78	0.0088*	0.310	0	0 *
12/29/78	0.0076*	0.267	0	0 *
12/30/78	0.0063*	0.224	0	0 *
12/31/78	0.0320*	1.13	19	0.75 *
01/01/79	0.0314*	1.11	5	0.20 *
01/02/79	0.0527*	1.86	20	0.80 *
01/03/79	0.0215	0.761	0	0
01/04/79	0.0215	0.761	0	0
01/05/79	0.0175	0.618	0	0
01/06/79	0.0133	0.469	0	0

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
01/07/79	0.0462	1.63	8	0.33
01/08/79	0.0586	2.07	21	0.81
01/09/79	0.0289	1.02	0	0
01/10/79	0.0199	0.701	2	0.10
01/11/79	0.0100	0.353	0	0
01/12/79	0.0073	0.257	0	0
01/13/79	0.0126	0.446	0	0
01/14/79	0.0111	0.393	0	0
01/15/79	0.0043	0.153	0	0
01/16/79	0.0026	0.092	0	0
01/17/79	0.0049	0.172	0	0
01/18/79	0.0103	0.363	10	0.40
01/19/79	0.0111	0.392	0	0
01/20/79	0.0682	2.41	15	0.60
01/21/79	0.122	4.30	37	1.45
01/22/79	0.0603	2.13	19	0.75
01/23/79	0.0337	1.19	0	0
01/24/79	0.0275	0.970	0	0
01/25/79	0.0167	0.591	0	0
01/26/79	0.0160	0.565	0	0
01/27/79	0.0191	0.673	7	0.28
01/28/79	0.0191	0.673	0	0
01/29/79	0.0175	0.618	0	0
01/30/79	0.0123	0.435	0	0
01/31/79	0.0133	0.469	1	0.03
02/01/79	0.0114	0.403	0	0
02/02/79	0.0111	0.393	0	0
02/03/79	0.0108	0.383	0	0
02/04/79	0.0100	0.353	0	0
02/05/79	0.0092	0.325	0	0
02/06/79	0.0092	0.325	0	0
02/07/79	0.0087	0.307	0	0
02/08/79	0.0087	0.307	0	0
02/09/79	0.0075	0.365	0	0
02/10/79	0.0060	0.212	0	0
02/11/79	0.0060	0.212	0	0
02/12/79	0.0060	0.212	0	0
02/13/79	0.0060	0.212	0	0
02/14/79	0.0060	0.212	0	0
02/15/79	0.0217	0.767	2	0.07
02/16/79	0.0453	1.60	13	0.50

Appendix A - DAILY PRECIPITATION AND FLOW VALUES CON'T

DATE	FLOW (M^3/sec)	FLOW (CFS)	PRECIPITATION (mm)	PRECIPITATION (Inches)
02/17/79	0.0294	1.04	8	0.30
02/18/79	0.0211	0.746	0	0
02/19/79	0.0247*	0.872	2	0.10 *
02/20/79	0.0168*	0.593	0	0 *
02/21/79	0.0156*	0.552	0	0 *
02/22/79	0.0121*	0.427	0	0 *
02/23/79	0.0086*	0.302	0	0 *
02/24/79	0.0413*	1.46	24	0.95 *
02/25/79	0.0589*	2.08	18	0.70 *
02/26/79	0.0521*	1.84	15	0.60 *
02/27/79	0.0416*	1.47	9	0.35 *
02/28/79	0.0337*	1.19	0	0 *

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
12/08/76	7.3-7.4	26-38	37-39
12/09/76	7.3-7.4	9-27	34-38
12/10/76	7.2-7.3	4-37	32-34
12/11/76	7.2-7.3	14-43	33-38
12/12/76	7.2-7.9	35-49	38-42
12/13/76	7.5-8.2	40-47	42-45
12/14/76	7.6-7.7	18-43	39-44
12/15/76	7.5-7.7	13-53	35-39
12/16/76	7.4-7.7	24-48	38-42
12/17/76	7.4-7.7	29-48	40-43
12/18/76	7.7-7.8	52-54	35-37
12/19/76	-	46	-
12/20/76	-	25-50	-
12/21/76	-	40-44	-
12/22/76	-	6-18	-
12/23/76	-	(-3)-18	-
12/24/76	-	22-27	-
12/25/76	-	5-25	-
12/26/76	-	16-25	-
12/27/76	-	22-25	-
12/28/76	-	19-26	-
12/29/76	-	28-40	-
12/30/76	-	17-23	-
12/31/76	-	5-34	-
01/01/77	-	11-24	-
01/02/77	8.2-8.4	(-4)-8	32
01/03/77	-	-2	-
01/04/77	-	11-18	-
01/05/77	7.5	11-30	-
01/06/77	-	27-32	-
03/09/77	7.8	58-70	48
03/10/77	-	68-78	52
03/11/77	-	65-70	55
03/12/77	-	63-70	-
03/13/77	-	67-70	-

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
03/14/77	-	75-85	-
03/15/77	-	58	-
03/16/77	7.7	56	54
03/17/77	7.7	38	50
03/18/77	8.3	65-70	65
03/19/77	-	46-50	-
03/20/77	-	63-65	-
03/21/77	7.2	41-43	50
03/22/77	-	48-57	-
03/23/77	-	40-45	-
03/24/77	-	50-62	-
03/25/77	-	57-68	-
03/26/77	-	65-75	-
03/27/77	-	65-70	-
03/28/77	7.7	62-65	57
03/29/77	-	78-84	-
03/30/77	-	68-82	-
03/31/77	-	65-72	-
04/01/77	-	72-81	-
04/02/77	-	75-85	-
04/03/77	-	65-75	-
04/04/77	7.5-8.4	52	52
04/05/77	-	55-60	-
04/06/77	7.4	42-53	61
04/07/77	-	62-70	-
04/08/77	-	60-67	-
04/09/77	-	60-70	-
04/10/77	-	75-82	-
04/11/77	7.5-8.0	50-78	60-64
04/12/77	7.5-7.8	48-88	57-69
04/13/77	7.5-7.8	50-91	60-68
04/14/77	7.5-7.7	50-90	61-67
04/15/77	7.4-7.5	51-91	64-69
04/16/77	7.5-7.6	51-88	63-73
04/17/77	7.4-7.6	51-88	64-72

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
04/18/77	7.4-7.6	56-92	67-74
04/19/77	7.4-7.6	62-84	70-74
04/20/77	7.4-7.7	58-89	68-73
04/21/77	7.3-7.7	60-85	69-75
04/22/77	7.3-7.7	65-82	70-72
04/23/77	7.5-8.1	60-76	65-72
04/24/77	7.2-7.8	47-68	65-66
04/25/77	7.3-7.4	42-67	63-65
04/26/77	7.2-7.5	47-62	62
04/27/77	7.3-7.7	42-72	52-66
04/28/77	7.3-8.4	53-69	60-63
04/29/77	7.4	50-72	58-67
04/30/77	7.4-7.6	65-78	57-67
05/01/77	7.3-8.2	62-77	67-68
05/02/77	7.2-7.7	65-83	66-72
05/03/77	7.0	65-73	72
05/04/77	7.2	67-80	69-72
05/05/77	7.4	65-79	71
05/06/77	6.8	70-96	77
05/07/77	6.6	67-90	74
05/08/77	-	60-90	-
05/09/77	-	60-80	-
05/10/80	6.2-6.3	48-75	59-62
05/11/77	6.2-6.6	43-82	56-64
05/12/77	6.0-6.5	46-85	57-66
05/13/77	6.0-6.4	50-91	60-68
05/14/77	5.9-6.3	54-85	62-68
05/15/77	5.8-6.3	59-95	64-72
05/16/77	5.9	59-83	60-66
06/18/77	6.9-7.5	-	70-76
06/19/77	6.5-7.6	-	70-80
06/20/77	6.8	-	74
06/21/77	6.8-7.3	-	71-75
06/22/77	4.7-7.6	-	68-71

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
06/23/77	6.3-7.4	-	69-72
06/24/77	6.4-7.2	-	67-71
06/25/77	6.4-6.7	-	67-74
06/26/77	6.6-7.3	-	69-77
06/27/77	4.2-7.5	-	70-74
06/28/77			
06/29/77	6.3-6.5	-	68-75
06/30/77			
07/01/77	5.4-6.2	75-81	67-69
07/02/77	5.3-6.5	75-85	66-76
07/03/77	5.4-6.2	78-87	69-79
07/04/77	5.5-6.8	77-83	69-75
07/05/77	5.6-7.1	80-86	70-78
07/06/77	5.6-7.2	79-86	72-80
07/07/77	7.0-7.5	81-88	72-79
07/08/77	5.4-6.8	80-86	72-78
07/09/77	5.3-7.4	79-83	71-79
07/10/77	7.1-7.3	80-87	72-80
07/11/77	7.0-7.6	79-88	72-76
07/12/77	6.1-7.7	79-84	71-77
07/13/77	6.2-7.5	79-86	71-79
07/14/77	6.8-7.3	80-88	73-80
07/15/77	6.2-7.6	80-87	73-80
07/16/77	6.2-7.5	80-87	74-80
07/17/77	6.6-7.0	81-89	74-79
07/18/77	6.2-7.2	82-86	74-78
07/19/77	5.8-7.3	80-85	73-78
07/20/77	6.2-7.2	87-83	74-80
07/21/77	6.2-7.5	83-87	75-79
07/22/77	5.7-7.3	77-83	67-76
07/23/77	7.2-7.8	75-80	69-75
07/24/77	5.8-7.5	78-80	71-74
07/25/80	5.8-7.0	77-79	71-74
07/26/77	6.2-6.8	74-80	71-74
07/27/77	6.5-6.9	73-76	67-72

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
07/28/77	6.6-6.8	74-78	67-72
07/29/77	5.7-7.2	74-75	69-70
07/30/77	6.6	74-80	70-75
07/31/77	6.6	75-80	70-73
08/01/77	6.7	75-78	72-74
08-02/77	6.6	74-80	68-73
08/03/77	6.1-6.6	77-80	71-75
08/04/77	6.1-6.8	75-81	71-76
08/05/77	6.1-6.7	77-78	72-75
08/06/77	6.6	75-79	71-75
08/07/77	6.6	76-81	72-76
08/08/77	6.6-7.0	76-79	71-73
08/09/77	6.5-7.0	67-87	70-80
08/10/77	6.7-6.9	67-97	73-80
08/11/77	5.2-7.2	68-88	75-79
08/12/77	4.9-6.7	70-83	73-75
08/13/77	6.3-6.7	72-86	72-75
08/14/77	6.3-6.4	68-90	72-78
08/15/77	6.4	70-86	73-79
08/16/77	6.5	-	73-80
08/17/77	6.4-6.6	63-76	71-75
08/18/77	6.5-6.6	57-76	66-75
08/19/77	6.4-6.6	57-78	65-72
08/20/77	6.4-6.7	55-78	66-71
08/21/77	6.5-6.6	55-81	64-71
08/22/77	6.5-6.6	62-85	68-72
08/23/77	6.5-6.7	62-85	67-73
08/24/77	6.5-6.7	65-75	70-74
08/25/77	6.5-6.7	64-85	69-73
08/26/77	6.5-6.7	62-88	69-73
08/27/77	6.5	64-85	70-73
08/28/77	6.5	65-93	70-74
08/29/77	6.5	65-92	71-74
08/30/77	6.4	67-84	72-73
08/31/77	6.5-6.6	65-83	71-77

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
09/13/77	5.0-7.0	71-77	67-71
09/14/77	6.2-6.5	69-91	73-80
09/15/77	-	72-76	73-75
09/16/77	-	70-87	71-78
09/17/77	6.4	64-75	65-71
09/18/77	6.3	63-81	67-72
09/19/77	6.5	64-78	68-71
09/20/77	6.5	63-84	68-71
09/21/77	6.4	62-83	68-70
09/22/77	6.3-6.4	62-80	67-70
09/23/77	6.3-6.5	56-77	65-69
09/24/77	6.4-6.6	49-70	63
09/25/77	6.4-6.5	49-80	61-64
09/26/77	6.4	52-76	61-64
09/27/77	6.4	57-73	63-67
09/28/77	6.4	60-76	64-66
09/29/77	6.3-6.4	62-79	66-68
09/30/77	6.3-6.6	63-69	64-67
10/01/77	6.4-6.5	48-63	60-64
10/02/77	6.3-6.5	47-67	58-62
10/03/77	4.7-6.3	55-70	65-69
10/04/77	5.6-5.7	47-58	62-67
10/05/77	5.2-6.1	43-65	58-65
10/06/77	5.7-6.1	-	58-63
10/07/77	6.1	-	58-63
10/08/77	5.8-6.8	55-70	57-67
10/09/77	6.0-6.2	-	65-66
10/10/77	5.9-6.0	-	64-68
10/11/77	5.8-5.9	-	62-67
10/12/77	5.8-5.9	-	53-64
10/25/77	6.0-6.5	54-61	57-60
11/06/77	5.7-6.7	62-75	65-71

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
03/30/78	6.2	37	52
03/31/78	6.1-6.3	37-79	50-62
04/01/78	6.2-6.4	47-80	54-65
04/02/78	6.2-6.3	48-85	56-67
04/03/78	5.6-6.2	54-83	57-68
04/04/78	6.2-6.3	52-80	59-67
04/05/78	6.2-6.3	53-84	60-70
04/06/78	6.2	53-85	60-67
04/07/78	6.2	58-81	62-71
04/08/78	6.2	43-84	55-63
04/09/78	6.2	48-87	58-72
04/10/78	6.2	54-87	63-74
04/11/78	6.3	42-74	57-67
04/12/78	6.2-6.3	39-75	55-67
04/13/78	6.2-6.3	43-73	52-68
04/14/78	6.3-6.5	38-70	52-65
04/15/78	6.3-6.4	45-68	57-66
04/16/78	6.2-6.5	40-66	53-63
04/17/78	6.2-6.3	46-73	58-65
04/18/78	6.1	50-70	61-66
04/19/78	6.2	48-67	59-63
04/20/78	6.0-6.1	40-48	52-57
04/21/78	6.0-6.1	40-47	51-54
04/22/78	6.2-6.5	40-68	50-62
04/23/78	6.2-6.3	39-67	57-64
04/24/78	6.0-6.1	43-80	60-74
04/25/78	5.7-6.1	45-66	58-74
04/26/78	5.2-6.1	43-48	52-65
08/17/78	6.2	69-75	75-77
08/18/78	6.1	67-86	74-83
08/19/78	5.9	67-94	81-93
08/20/78	5.7	62-85	90
08/21/78	5.7	59-84	80-91

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
08/22/78	5.7	-	-
08/23/78	5.7	-	-
08/24/78	5.7	-	-
08/25/78	5.7	-	-
08/26/78	5.5-5.7	-	-
08/27/78	5.7	-	-
08/27/78	5.7	-	-
11/18/78	6.4-7.0	56	49
11/19/78	6.7	45-55	56-58
11/20/78	5.0-6.7	37-65	60-69
11/21/78	6.8	40-46	66-69
11/22/78	6.0	38-51	61-63
11/23/78	4.8-6.1	50	68
11/24/78	6.0-6.3	30-55	59-65
11/25/78	5.8-6.0	31-40	55-62
11/26/78	5.8-6.2	30-37	54-67
11/27/78	4.0-5.6	37-52	55-63
11/28/78	5.6-5.8	29-49	59-63
11/29/78	5.6-6.2	27-37	52-59
11/30/78	5.2-5.8	31-41	54-58
12/01/78	5.9-6.1	25-50	53-57
12/02/78	5.0	27-52	53-55
12/03/78	5.3-6	37-57	55-62
12/04/78	4.9-5.9	38-55	59-66
12/05/78	5.6-5.7	29-48	56-63
12/06/78	5.5-5.7	24-48	51-57
12/07/78	5.2-5.6	27-56	51-57
12/08/78	4.9-5.3	47-62	55-71
12/09/78	4.7-5.3	24-55	52-71
01/03/79	6.1-6.6	20-25	42
01/04/79	6.6-6.9	16-37	41-46
01/05/79	6.7	28-37	42-45
01/06/79	6.7	34-40	44-45
01/07/79	4.8-6.7	37-53	42-51

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
01/08/79	4.0-5.9	22-37	51-57
01/09/79	4.0-4.9	15-33	52-57
01/10/79	4.2-4.9	28-38	52-60
01/11/79	4.5-5.3	24-34	51-59
01/12/79	4.6-5.2	28-47	52-59
01/13/79	5.0-6.0	38-55	57-63
01/14/79	5.7-6.1	27-51	54-66
01/15/79	5.0-6.0	15-33	49-57
01/16/79	4.9-5.4	27-41	52-62
01/17/79	5.3-5.7	37-49	55-65
01/18/79	5.6-5.9	29-47	58-61
01/19/79	5.7-6.0	28-41	54-57
01/20/79	6.0-6.3	39-50	56-62
01/21/79	6.1-6.7	32-47	56-63
01/22/79	6.2-6.9	27-34	52-59
01/23/79	6.6-7.0	25-46	52-59
01/24/79	6.7-6.8	22-44	52-57
01/25/79	6.7-6.8	22-31	49-57
01/26/79	6.8-7.0	16-37	48-59
01/27/79	6.9-7.0	24-48	51-59
01/28/79	6.9-7.3	29-35	52-61
01/29/79	7.0-7.4	28-32	52-61
01/30/79	7.0-7.3	28-41	52-59
01/31/79	7.2	24-31	53-60
02/01/79	7.5	20-23	52-59
02/02/79	6.4-7.0	13-37	42-57
02/03/79	7.6-7.8	29-40	54-65
02/04/79	7.7-7.8	31-43	57-60
02/05/79	7.7-8.0	19-31	54-65
02/06/79	7.8-7.9	18-41	52-60
02/07/79	7.9-8.0	34-40	56-59
02/08/79	7.9-8.0	27-46	54-63
02/09/79	7.9-8.0	15-34	54-62
02/10/79	7.9-8.1	10-32	52-62
02/11/79	8.0-8.3	21-47	52-66

Appendix A - Daily pH, Temperature

Date	pH	Air Temperature (range, °F)	Water Temperature (range, °F)
02/12/79	7.9-8.1	30-43	56-59
02/13/79	7.9-8.0	29-35	54-60
02/14/79	8.0-8.1	29-47	54-66
02/15/79	8.0	41-60	59-63
02/16/79	8.0-8.2	28-56	57-65
02/17/79	8.0-8.2	23-33	52-60
02/18/79	8.2	29-35	52-60

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
12/08/76	0-28	
12/09/76	0-7	
12/10/76	0	
12/11/76	0	
12/12/76	0-2344	
12/13/76	0-2338	
12/14/76	0	
12/15/76	0	
12/16/76	0	
12/17/76	0	
12/18/76	0	
12/19/76	-	
12/20/76	-	
12/21/76	-	
12/22/76	-	
12/23/76	-	
12/24/76	-	
12/25/76	-	
12/26/76	-	
12/27/76	-	
12/28/76	-	
12/29/76	-	
12/30/76	-	
12/31/76	-	
01/01/77	-	
01/02/77	0-113	
01/03/77	-	
01/04/77	-	
01/05/77	-	152 (Grab sample)
01/06/77	-	
03/09/77	-	164 (Grab sample)
03/10/77	-	
03/11/77	-	
03/12/77	-	
03/13/77	-	

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
03/14/77	-	
03/15/77	-	
03/16/77	0	
03/17/77	0	
03/18/77	0	
03/19/77	-	
03/20/77	-	
03/21/77	30	
03/22/77	-	
03/23/77	-	
03/24/77	-	
03/25/77	-	
03/26/77	-	
03/27/77	-	
03/28/77	-	
03/29/77	-	
03/30/77	-	
03/31/77	-	
04/01/77	-	
04/02/77	-	
04/03/77	-	
04/04/77	0-2400	
04/05/77	-	
04/06/77	-	
04/07/77	-	
04/08/77	-	
04/09/77	-	
04/10/77	-	
04/11/77	30	
04/12/77	20	
04/13/77	10	
04/14/77	0	
04/15/77	0	
04/16/77	0	
04/17/77	0	

Appendix A - Turbidity, Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
04/18/77	0	
04/19/77	0	
04/20/77	0	
04/21/77	0	
04/22/77	0	
04/23/77	0-2400	
04/24/77	20-2050	
04/25/77	10	
04/26/77	10	
04/27/77	10	
04/28/77	0-2400	
04/29/77	30	
04/30/77	0	
05/01/77	0-2400	
05/02/77	50-2400	
05/03/77	30-80	
05/04/77	30	
05/05/77	30-2400	
05/06/77	40	
05/07/77	30	
05/08/77	-	
05/09/77	-	
05/10/80	20	
05/11/77	20	220 (Grab sample)
05/12/77	0	
05/13/77	0	
05/14/77	0	
05/15/77	0	
05/16/77	0	
06/18/77	160-2400	
06/19/77	80-2400	
06/20/77	90-330	
06/21/77	60-2400	
06/22/77	150-2400	

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
06/23/77	410-2400	
06/24/77	180-2400	
06/25/77	70-2000	
06/26/77	50-2400	
06/27/77	0-2400	
06/28/77		
06/29/77	0-190	
06/30/77		
07/01/77	60-450	220
07/02/77	0-950	220-230
07/03/77	0	230-240
07/04/77	0	240-250
07/05/77	0	250
07/06/77	0	250
07/07/77	0	250
07/08/77	0-2400	250-490
07/09/77	80-2400	210-475
07/10/77	60-80	280-300
07/11/77	0-50	270-280
07/12/77	0	270
07/13/77	0	270
07/14/77	0	270
07/15/77	0	270
07/16/77	0	270-280
07/17/77	0	280
07/18/77	0	270-280
07/19/77	0	280
07/20/77	0	290
07/21/77	0	280-290
07/22/77	0	280-290
07/23/77	0	280
07/24/77	0	260-290
07/25/80	0	290
07/26/77	0	290
07/27/77	0	290

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
07/28/77	0	290
07/29/77	0-2400	280-430
07/30/77	0	300
07/31/77	0	290
08/01/77	0	290
08-02/77	0	290
08/03/77	0	290
08/04/77	0-2400	100-290
08/05/77	0-2400	1000
08/06/77	0-30	315-360
08/07/77	0	310-315
08/08/77	0-2400	300-525
08/09/77	0-2400	310-670
08/10/77	0-40	330-420
08/11/77	0-2400	220-490
08/12/77	70-2400	210-540
08/13/77	0-1600	290-360
08/14/77	0	320
08/15/77	0	310-320
08/16/77	0	310-320
08/17/77	0	310-340
08/18/77	0	320-340
08/19/77	0	320
08/20/77	0	310
08/21/77	0	310
08/22/77	0	310
08/23/77	0	310
08/24/77	0-2400	310-800
08/25/77	0	310-320
08/26/77	0	320
08/27/77	0	310
08/28/77	0	310
08/29/77	0	310-320
08/30/77	0	310
08/31/77	0-2400	310-640

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
09/13/77	0-2400	180-590
09/14/77	70-800	350-460
09/15/77	0-70	340-350
09/16/77	0	350
09/17/77	0-2400	320-630
09/18/77	0	350-380
09/19/77	0	340-350
09/20/77	0	340
09/21/77	0	340
09/22/77	0	340
09/23/77	0	340
09/24/77	0	340
09/25/77	0	340
09/26/77	0	340
09/27/77	0	340
09/28/77	0	340
09/29/77	0-670	340-630
09/30/77	0-2400	350-650
10/01/77	0	340-350
10/02/77	0	340
10/03/77	0-2400	140-510
10/04/77	0	290-330
10/05/77	0-2400	280-390
10/06/77	0-170	280-290
10/07/77	0	290-460
10/08/77	0-2400	230-320
10/09/77	210-1350	240-280
10/10/77	80-2400	250-320
10/11/77	30-80	270
10/12/77	20-2400	260-320
10/25/77	0-1670	315-330
11/06/77	0-1800	250-320
03/30/78	0	690
03/31/78	0-20	690-720
04/01/78	0-20	700-730
04/02/78	0-50	710-750
04/03/78	50-2400	730-810

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
04/04/78	90-2070	730-780
04/05/78	100-2400	760-820
04/06/78	100-2400	620-830
04/07/78	100-180	760-780
04/08/78	40-110	750-790
04/09/78	80-130	770-790
04/10/78	80-100	780
04/11/78	0	790
04/12/78	0	780-810
04/13/78	0	790-810
04/14/78	0	780-810
04/15/78	0-70	790-810
04/16/78	0	770-800
04/17/78	0	785-800
04/18/78	0-70	770-810
04/19/78	0	770-800
04/20/78	0	770-800
04/21/78	0	770-790
04/22/78	0	770-810
04/23/78	0	770-800
04/24/78	0	770-800
04/25/78	0-1970	760-1000+
04/26/78	100-2400	550-970
08/17/78	70	415
08/18/78	70	420
08/19/78	70	420
08/20/78	40	410
08/21/78	20	420
08/22/78	20	420
08/23/78	10	420
08/24/78	0	420
08/25/78	0-800	420-520
08/26/78	0-290	450-520
08/27/78	0	450
08/27/78	0	450-520

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
11/18/78	0	520 (Grab sample)
11/19/78	0	-
11/20/78	0	500
11/21/78	0	500
11/22/78	0	510
11/23/78	20	470
11/24/78	0	500-520
11/25/78	0	500-520
11/26/78	0-2400	370-490
11/27/78	0-550	-
11/28/78	0	-
11/29/78	0-70	450-460
11/30/78	0	440-450
12/01/78	0	430-450
12/02/78	0	430-440
12/03/78	0-140	400
12/04/78	2400	190-410
12/05/78	140-450	360
12/06/78	100-150	350
12/07/78	50-100	240-300
12/08/78	190-2400	140-280
12/09/78	500-2400	90-210
01/03/79	0	290
01/04/79	0	290-320
01/05/79	0	320-340
01/06/79	0-100	340-350
01/07/79	100-2400	220-350
01/08/79	480-2400	-
01/09/79	230-1680	-
01/10/79	0-390	-
01/11/79	180-190	-
01/12/79	140-180	-
01/13/79	80-140	-
01/14/79	60-80	-
01/15/79	20-50	-
01/16/79	0-20	-
01/17/79	20-80	-

Appendix A - Turbidity and Conductivity Values

Date	Turbidity (range, NTU)	Conductivity (range umhos/cm)
01/18/79	50-80	-
01/19/79	80-100	-
01/20/79	100-120	-
01/21/79	120-140	-
01/22/79	100-160	-
01/23/79	80-140	-
01/24/79	80-140	-
01/25/79	0-80	-
01/26/79	0-1340	-
01/27/79	0-1560	-
01/28/79	0-1560	-
01/29/79	0-20	-
01/30/79	0	-
01/31/79	0	-
02/01/79	0	-
02/02/79	0	-
02/03/79	140-190	-
02/04/79	110-190	-
02/05/79	0-80	-
02/06/79	0	-
02/07/79	0-20	-
02/08/79	20-80	-
02/09/79	80-120	-
02/10/79	140-170	-
02/11/79	80-140	-
02/12/79	20-80	-
02/13/79	20	-
02/14/79	20-60	-
02/15/79	60-80	-
02/16/79	80	-
02/17/79	80-110	-
02/18/79	80-110	350 (Grab sample)

APPENDIX B

Water Quality Analyses for the Grab Samples collected at Rhoades Branch upstream, Rhoades Branch downstream and Dick Branch.

All samples were analyzed according to procedures outlined by the EPA in "Methods for Chemical Analysis of Water and Wastes".

Turbidity - Nephelometric Method

pH - Electrometric measurement using a Leeds and Northrup model 7417-L2 pH meter.

Total Alkalinity - Titrimetric method to pH 4.5

Metals (Calcium, Magnesium, Iron and Manganese) - Atomic Absorption Method

Hardness - Titrimetric Method

Sulfate - Turbidimetric Method

Hot Acidity - Titrimetric Method to pH 8.2

Conductivity - Specific Conductance measured with a conductivity meter at 25° C

Solids, Total - Sample dried to constant weight at 103-105° C

Suspended - Sample was filtered through a standard glass fiber filter then the filter was dried to constant weight at 103-105°

Dissolved - Determined by calculation Total - Suspended = Dissolved

The monthly grab sampling locations are as follows:

Rhoades Branch Upstream: Samples were collected at the point where Rhoades Branch flows into Debris Basin #1. See Figure 6.

Dick Branch: All grab samples were collected near the mouth of Dick Branch at the boundary of the study area as shown on Figure 2.

Rhoades Branch Upstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
1/27/75	3.8	6.6	12	3.87	24	2.92	0.08	0.01	25	2	81	0	48	48
2/27/75	2.5	7.6	8	1.69	28	3.19	0.04	<0.01	28	2	85	0	68	68
3/20/75	5.3	6.8	38	2.85	34	3.22	0.10	<0.01	30	3		6	63	69
4/18/75	3.3	6.85	14	1.18	30	2.59	0.06	<0.01	44	2	85	4	47	51
5/29/75	29	7.0	18	5.37	28	2.17	0.50	<0.01	15	1	60	29	62	91
6/23/75	0.4	7.4	9	73.3	274	19.2	<0.02	<0.01	675	2	1050	8	929	937
7/23/75	72	6.1	22	1.82	30	5.53	1.17	<0.01	33	4	68	91	68	159
8/27/75	7.3	6.7	18	2.37	28	5.41	0.23	<0.01	15	3	71	8	24	32
9/29/75	3.4	6.1	16	2.90	24	2.58	0.22	<0.01	16	2	66	2	55	57
10/30/75	1.5	6.7	26	2.02	44	4.70	0.03	<0.01	27	14	110	1	98	99
11/20/75	4.3	6.35	10	1.34	24	2.59	0.23	<0.01	16	3	72	8	73	81
12/30/75	0.82	5.9	28	15.4	72	12.5	0.02	<0.01	42	2	270	4	187	191
1/26/76	29	6.1	8	0.82	36	4.40	0.60	<0.01	22	4	47	39	47	86
2/28/76	2.3	7.47	18	4.34	34	2.79	0.06	<0.01	27	1	81	0	63	63

NOTE: All units are mg/l except where noted.

Rhoades Branch Upstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
3/28/76	6.4	6.9	14	7.3	30	6.2	0.11	<0.01	26	6	70	9	66	75
9/8/76	7.5	7.4	48	15.5	64	5.2	0.2	0.03	22	4	145	9	91	100
10/6/76	1.0	8.0	43	21.0	64	6.3	0.1	0.02	23	1	144	3	92	95
10/13/76		7.3	28	24	64	7.1	0.1	0.0	26	2	150	< 1	100	100
11/19/76	1.7	7.3	38	17.9	63	5.1	0.1	0.0	30	3	156	3	103	106
12/7/76	80	6.8	20	19	56	5.1	0.4	0.1	39	2	150	88	121	209
1/5/77	1.7	7.5	29	19.4	48	3.7	0.11	0.01	29	1	149	7	83	90
2/24/77	120	6.2	12	8.2	46	5.3	0.75	0.07	37	8	143	120	132	252
3/9/77	3.2	7.6	25	14.7		5.9	0.14	0.01	42	2	157	2	108	110
5/11/77	2.0	7.5	34	22.4	90	8.4	0.3	0.2	70	3	217	10	157	167
6/2/77	4.9	7.1	43	25	104	9.5	0.52	0.4	80	8	240	1	80	81
6/9/77	130	6.8	26	26	124	14	2.02	0.16	191	9	262	204	226	430
8/11/77	4.8	7.2	68	30.8	136	13	0.17	0.02	97	9	290	2	101	103
9/1/77	23	7.2	56	34	168	18	0.43	0.08	156	3	405	28	264	292

NOTE: All units are mg/l exept where noted.

Rhoades Branch Upstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
9/21/77	3.9	6.5	62	34	164	15	0.14	0.04	130	6	380	3	235	238
10/5/77	24	6.75	34	33	177	18	0.53	0.53	170	6	415	34	286	320
10/23/77	3.6	7.05	27	32.4	158	16.8	0.12	0.12	124	4	365	7	284	291
12/14/77	130	6.8	42	16	132	28	1.01	0.22	365	5	300	205	229	434
3/30/78	20	6.8	42	26.4	124		0.21	0.05	100	6	308	26	204	230
5/4/78	290	6.9	42	39	190		4.78	0.52	165	6	165	826	435	1261
7/12/78	50	6.9	92	47.4		18.5	0.92	0.15	160	8	461	55	301	356
8/17/78	18	7.8	70		186		0.46	0.50	135	3	423	11	260	271
11/18/78	5.4	7.15	71		230		0.18	0.18	189	7	510	13	165	178
1/3/79	5.2	6.6	32	18.9	138		0.82	0.18		11	320	43	204	247
2/18/79	18	6.65	38		160				139	6	370	36	255	291
3/29/79	5.2	6.25	37		160		0.20	0.09	130	8	372	12	267	279

NOTE: All units are mg/l exept where noted.

Rhoades Branch Downstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
1/27/75	3.5	6.6	16	4.62	28	3.22	0.21	0.01	27	3	87	7	35	42
2/27/75	3.3	7.5	22	4.42	40	4.10	0.01	<0.01	35	2	119	7	79	86
3/20/75	5.8	6.9	18	2.69	34	3.49	0.11	<0.01	31	3		5	60	65
4/18/75	1.9	6.85	22	1.84	42	3.01	0.06	<0.01	47	1	110	3	75	78
5/29/75	27	7.0	8	2.93	20	2.11	0.50	<0.01	12	2	49	25	33	58
6/23/75	0.4	7.4	86	72.5	276	25.5	0.03	<0.01	675	4	1090	10	927	937
7/23/75	62	6.3	24	1.64	30	5.44	0.58	<0.01	30	4	68	68	52	120
8/27/75	3.5	6.65	20	2.33	30	5.90	0.26	<0.01	14	4	64	1	37	38
9/29/75	4.3	6.4	16	2.92	28	2.56	0.22	<0.01	17	2	68	2	57	59
10/30/75	0.65	7.0	44	5.14	58	5.63	0.02	<0.01	26	5	140	0	91	91
11/20/75	8.7	6.5	12	1.29	26	2.47	0.25	<0.01	18	3	68	11	51	62
12/30/75	1.0	6.05	26	16.06	70	12.33	0.02	0.02	40	2	410	0	188	188
1/26/76	37	6.1	6	1.47	30	4.40	0.49	<0.01	22	4	51	50	41	91
2/28/76	1.4	7.07	20	5.00	42	4.01	0.04	<0.01	35	4	100	0	64	64

NOTE: All units are mg/l exept where noted.

Rhoades Branch Downstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
3/28/76	6.2	6.9	14	7.6	30	6.3	0.23	<0.01	27	8	70	11	73	84
10/6/76	2.0	7.8	62	13.2	86	8.0	0.4	0.0	37	2	199	0	130	130
10/13/76	5.5	7.1	39	27	74	8.6	0.1	0.0	35	4	166	<1	110	110
11/19/76	1.8	7.1	30	14.9	65	5.5	0.0	0.0	34	4	159	2	98	100
12/7/76	55	6.8	31	19	58	5.6	0.2	0.0	40	4	156	28	116	144
1/5/77	1.0	7.5	31	20.4	44	4.0	0.03	0.0	19	2	152	1	89	90
2/24/77	.13	6.7	18	9.0	48	5.7	0.97	0.08	38	6	131	157	118	275
3/9/77	5.5	7.5	30	16.1		6.4	0.14	0.01	44	1	164	2	112	114
5/11/77	4.5	7.9	40	22	91	8.4	0.3	0.2	71	1	220	10	162	172
6/2/77	7.3	7.1	47	25	106	10.0	0.32	0.2	80	9	245	5	75	80
6/9/77	250	6.5	27	27	126	16	2.68	0.21	190	11	255	315	258	573
8/11/77	7.7	7.2	71	30.4	138	14.2	0.24	0.05	95	3	340	7	96	103
9/1/77	12	7.4	59	36	178	19	0.28	0.04	159	4	415	9	279	288
9/21/77	6.4	6.6	65	33	164	16	0.32	0.04	129	6	380	11	232	243

NOTE: All units are mg/l except where noted.

Rhoades Branch Downstream	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
10/5/77	22	6.85	37	32	175	18	0.42	0.39	156	6	415	31	278	309
10/23/77	2.8	7.0	50	31	150	16.4	0.15	0.08	115	11	355	8	264	272
12/14/77	110	6.8	43	15	126	28.5	1.04	0.21	310	6	292	259	182	441
3/30/78	20	6.9	39	25.6	120		0.24	0.05	100	6	302	35	197	232
5/4/78	310	6.9	41	39	182		5.07	0.50	174	6	460	983	325	1308
7/12/78	55	6.9	78	46.1		18.5	0.90	0.12	165	8	469	53	340	393
8/17/78	22	7.9	69		186		0.43	0.34	130	3	429	16	238	254
11/18/78	4.0	7.25	71		232		0.06	0.18	183	8	520	2	169	171
1/3/79	2.1	6.9	36	19.4	136		1.27	0.20		6	310	34	222	256
2/18/79	20	6.9	38		153				133	5	350	43	241	284
3/29/79	7.8	6.5	39		146		0.32	0.08	134	6	363	33	238	271

NOTE: All units are mg/l except where noted.

Dick Branch	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
1/27/75	3.6	6.9	24	5.81	32	3.29	0.14	0.01	25	3	110	0	50	50
2/27/75	5.2	8.0	28	8.41	52	5.06	0.07	<0.01	38	2	176	1	118	119
3/20/75	4.0	6.8	36	4.62	42	4.11	0.04	<0.01	27	7		5	89	94
4/18/75	2.3	8.65	54	3.60	48	4.77	0.03	<0.01	58	0	170	4	109	113
5/29/75	7.9	6.6	6	2.47	22	2.84	0.18	<0.01	20	2	51	5	87	92
6/23/75	1.0	7.8	124	15.5	82	8.0	0.03	<0.01	69	2	270	11	104	115
7/23/75	48	6.0	12	0.96	26	6.14	1.21	<0.01	26	6	62	108	86	194
8/27/75	6.7	6.6	19	2.11	24	5.45	0.20	<0.01	13	3	62	12	38	50
9/29/75	4.2	6.5	10	1.69	22	2.87	0.04	<0.01	19	3	57	2	50	52
10/30/75	1.5	7.35	100	11.6	80	6.61	0.02	<0.01	35	3	270	0	158	158
11/20/75	2.9	6.5	6	1.00	26	3.51	0.05	<0.01	23	2	70	6	96	102
12/30/75	3.4	6.3	44	8.14	46	7.91	0.12	<0.01	24	3	155	5	91	96
1/26/76	3.8	6.0	6	1.6	28	7.80	0.08	<0.01	27	4	70	51	6	57
2/28/76	1.3	7.35	48	7.56	56	5.17	0.06	<0.01	46	4	160	8	84	92

NOTE: All units are mg/l except where noted.

Dick Branch	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
3/28/76	6.8	7.1	24	7.7	34	6.9	0.26	0.01	29	6	90	11	97	108
9/8/76		8.0	182	25.0	104	8.4	0.1	0.01	52	1	430	4	279	283
10/6/76	1.6	8.0	161	20.1	94	9.3	0.8	0.0	44	1	374	1	238	239
10/13/76	2.1	7.8	99	28.2	68	10	0.2	0.0	37	2	255	4	147	151
11/19/76	2.0	7.9	107	16.0	74	5.8	0.1	0.0	35	1	267	5	171	176
12/7/76	22	6.8	22	14	28	2.8	0.2	0.0	26	3	111	22	77	99
1/5/77	2.4	7.9	44	17.5	54	3.0	0.08	0.01	26	1	151	6	91	97
2/24/77	17	6.2	15	6.0	28	3.2	0.16	0.02	22	11	105	20	82	102
3/9/77	0.75	8.0	50	13.7		4.8	0.11	0.01	34	1	167	< 1	124	124
5/11/77	0.65	8.4	72	17	70	5.6	0.1	0.1	46	0	220	5	152	157
6/2/77	1.0	7.6	127	29	96	9.0	0.29	0.1	62	9	330	2	116	118
6/9/77	1.5	7.4	115	20	80	8	0.42	0.02	51	12	282	16	220	236
9/21/77	1.5	6.9	171	19	92	8	0.07	0.03	37	6	315	2	177	179
10/5/77	2.6	7.1	59	11	52	4	0.14	0.01		3	190	2	105	107

NOTE: All units are mg/l except where noted.

Dick Branch	TURBIDITY (NTU)	pH	TOTAL ALKALINITY	CALCIUM	HARDNESS	MAGNESIUM	IRON	MANGANESE	SULFATE	HOT ACIDITY	CONDUCTIVITY mhos/cm	SUSPENDED SOLIDS	DISSOLVED SOLIDS	TOTAL SOLIDS
10/23/77	1.6	7.35	48	9.3	42	4.4	0.08	0.02	24	5	147	4	110	114
12/14/77	2.1	7.05	44	4.6	44	11.2	0.09	0.01	58	4	148	4	89	93
3/30/78	4.0	7.1	35	10.4	42		0.1	0.01	32	4	150	6	99	105
5/4/78	22	7.0	32	9	40		0.33	0.03	33	2	142	24	95	119
7/12/78	3.0	7.2	138	26.9		7.5	0.27	0.01	56	10	365	6	224	230
8/17/78	2.1	8.0	101		81		0.12	0.01	35	2	290	< 1	121	121
11/18/78		7.75	114		76		0.12	0.01		3				
1/3/79	2.2	6.9	32	3.3	29		0.21	0.01		6	100	7	59	66
2/18/79	2.4	7.15	27		34				< 10	3	122	2	81	83
3/29/79	2.7	7.05	33		38		0.10	0.01	28	4	151	4	92	96

NOTE: All units are mg/l except where noted.

APPENDIX C

Contained herein are the grain size distribution curves of the sediment deposited in the debris basins, during the course of the study, and the depth from surface at which they were obtained. The depths are in English units of measurement. A conversion table for metric units is located on page viii.

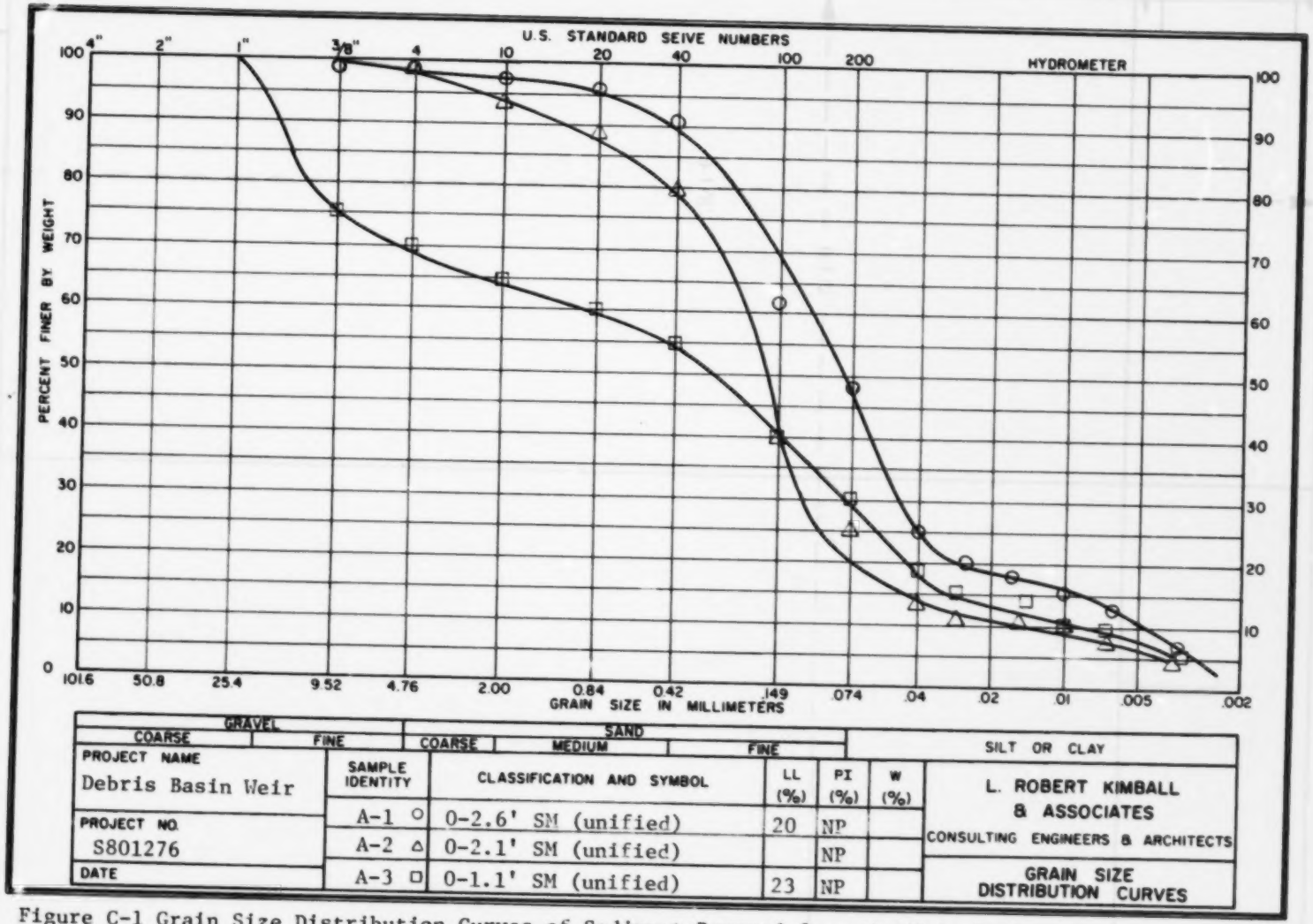


Figure C-1 Grain Size Distribution Curves of Sediment Removed from the Weir Pool.

2/78

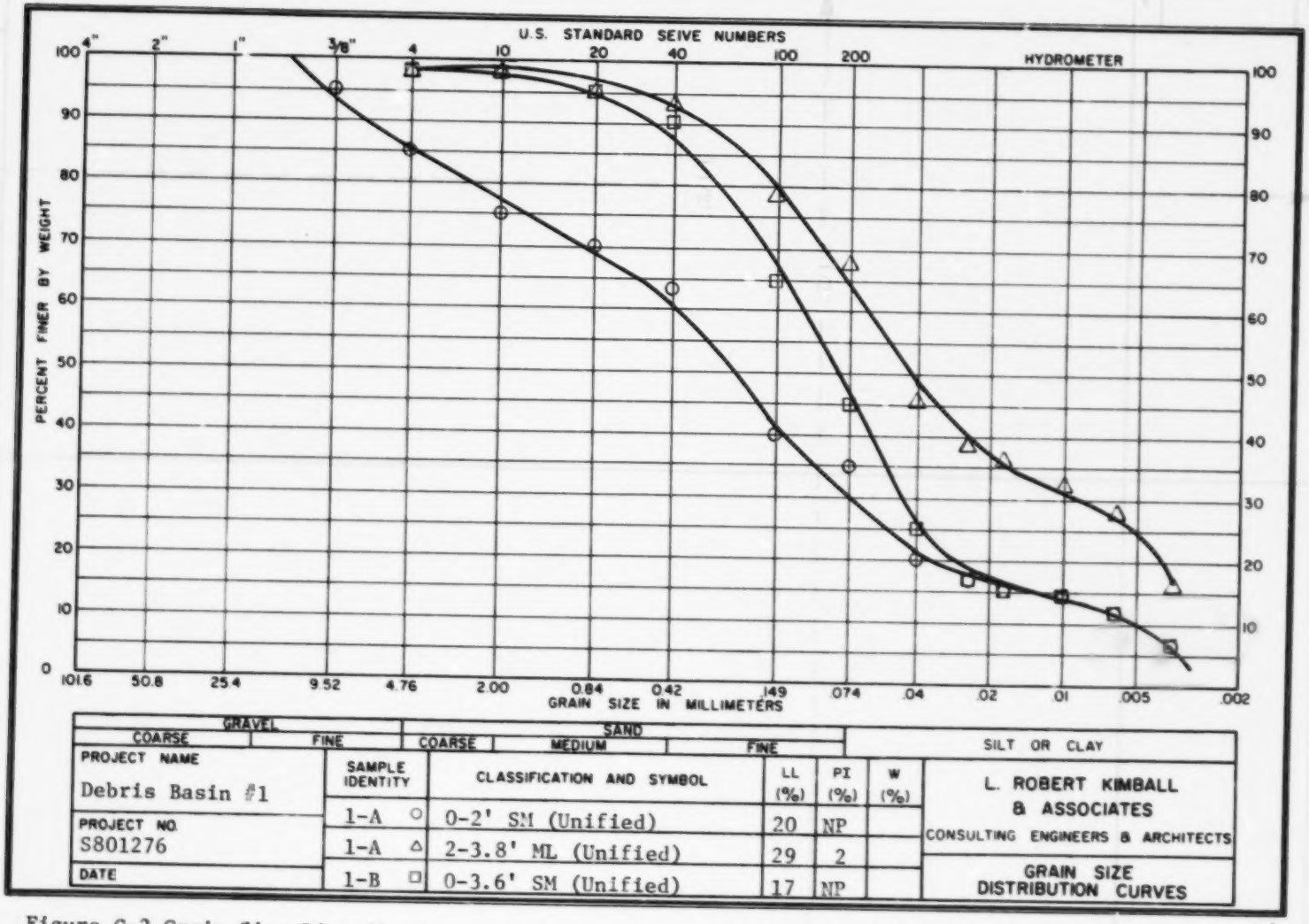
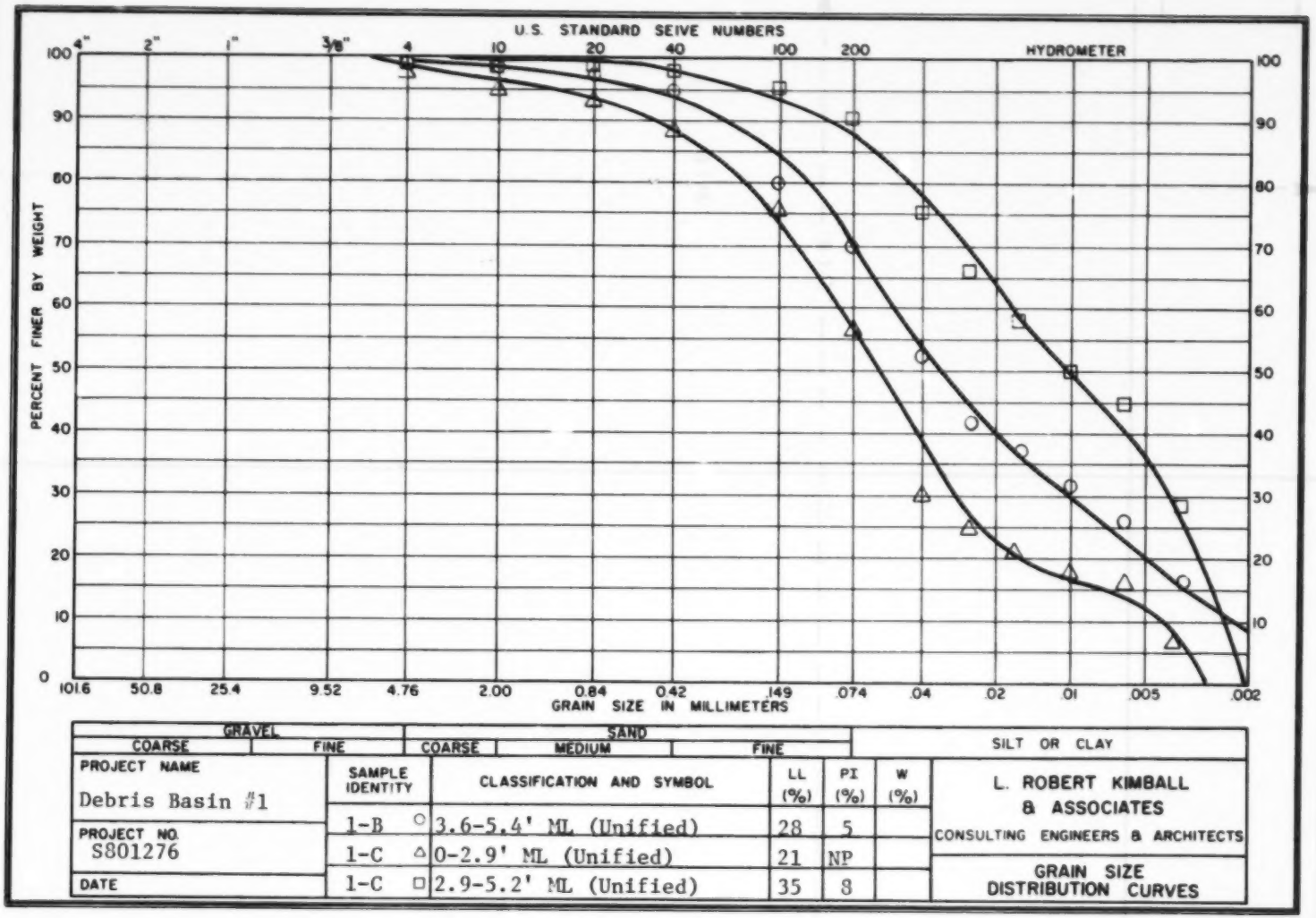


Figure C-2 Grain Size Distribution Curves of Sediment Removed from Basin #1.

2/78


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL COARSE FINE
SAND COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #1
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
1-B ○ 3.6-5.4' ML (Unified) 28 5
1-C △ 0-2.9' ML (Unified) 21 NP
1-C □ 2.9-5.2' ML (Unified) 35 8
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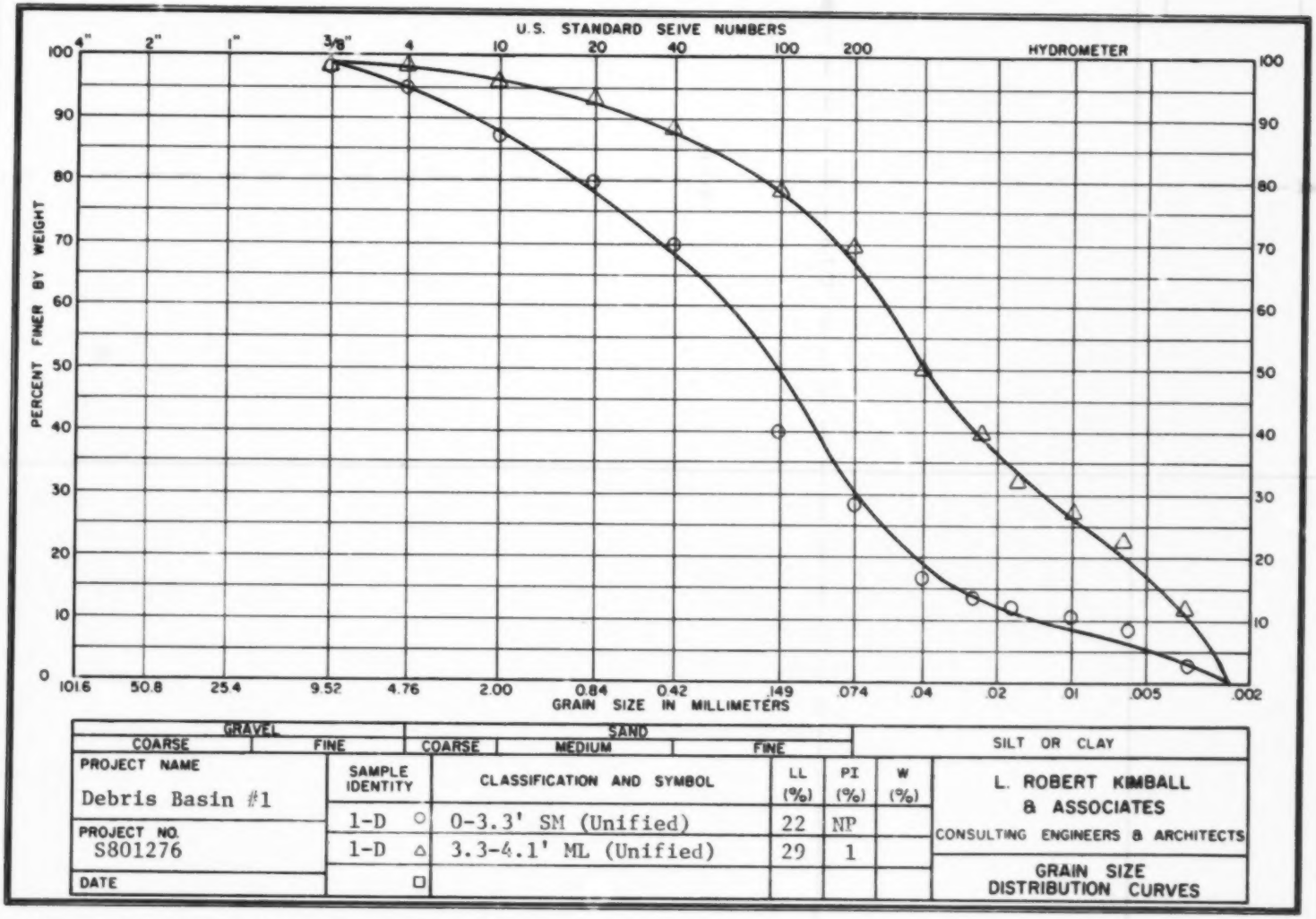
GRAIN SIZE DISTRIBUTION CURVES

Figure C-3 Grain Size Distribution Curves of Sediment Removed from Basin #1.

2/78


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
1016 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL
COARSE FINE
SAND
COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #1
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
1-D ○ 0-3.3' SM (Unified) 22 NP
1-D △ 3.3-4.1' ML (Unified) 29 1
□
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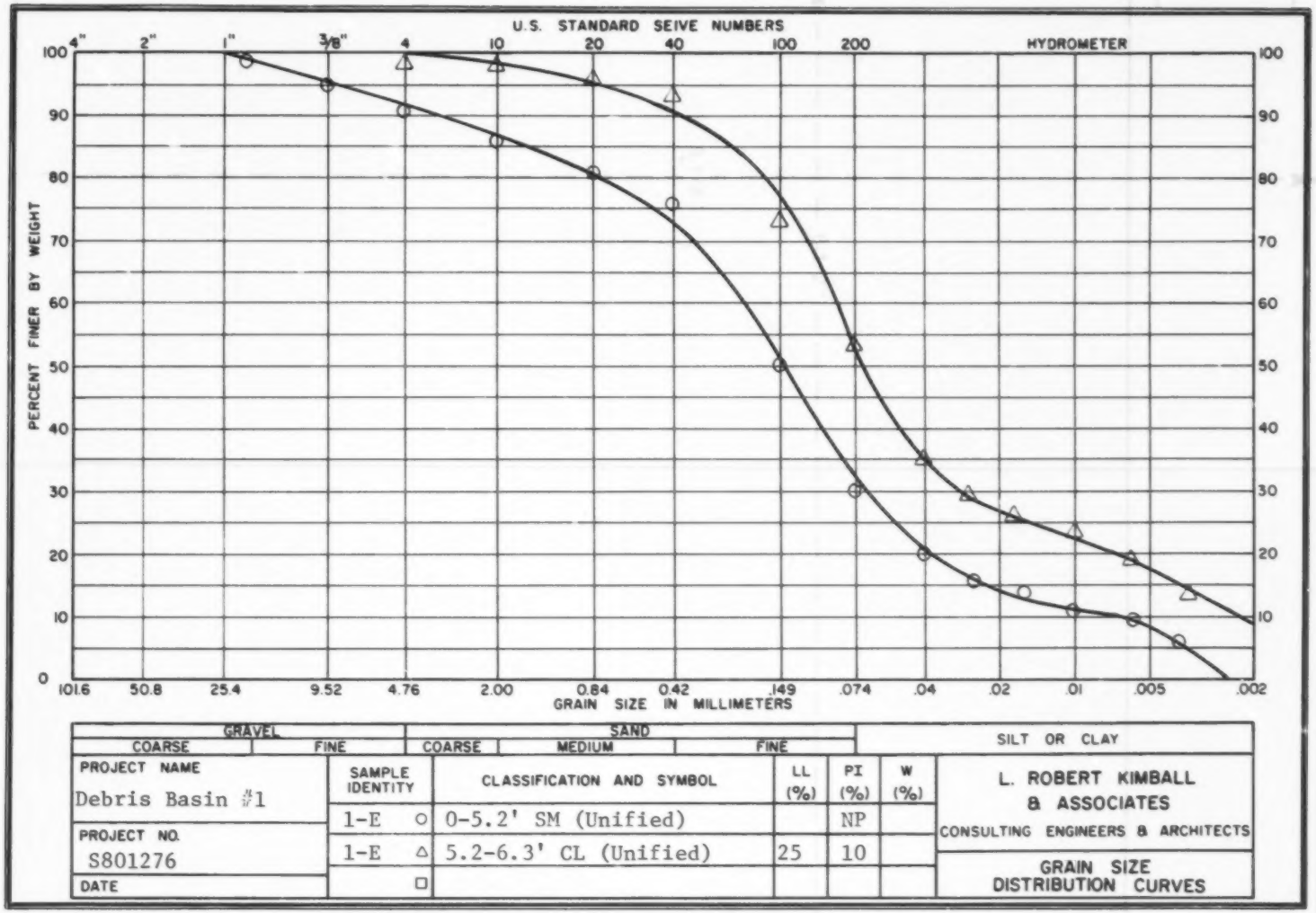
GRAIN SIZE DISTRIBUTION CURVES

Figure C-4 Grain Size Distribution Curves of Sediment Removed From Basin #1.

2/78


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL COARSE FINE
SAND COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #1
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
1-E ○ 0-5.2' SM (Unified) NP
1-E △ 5.2-6.3' CL (Unified) 25 10
□
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CONSULTING ENGINEERS & ARCHITECTS
GRAIN SIZE DISTRIBUTION CURVES

Figure C-5 Grain Size Distribution Curves of Sediment Removed From Basin #1.

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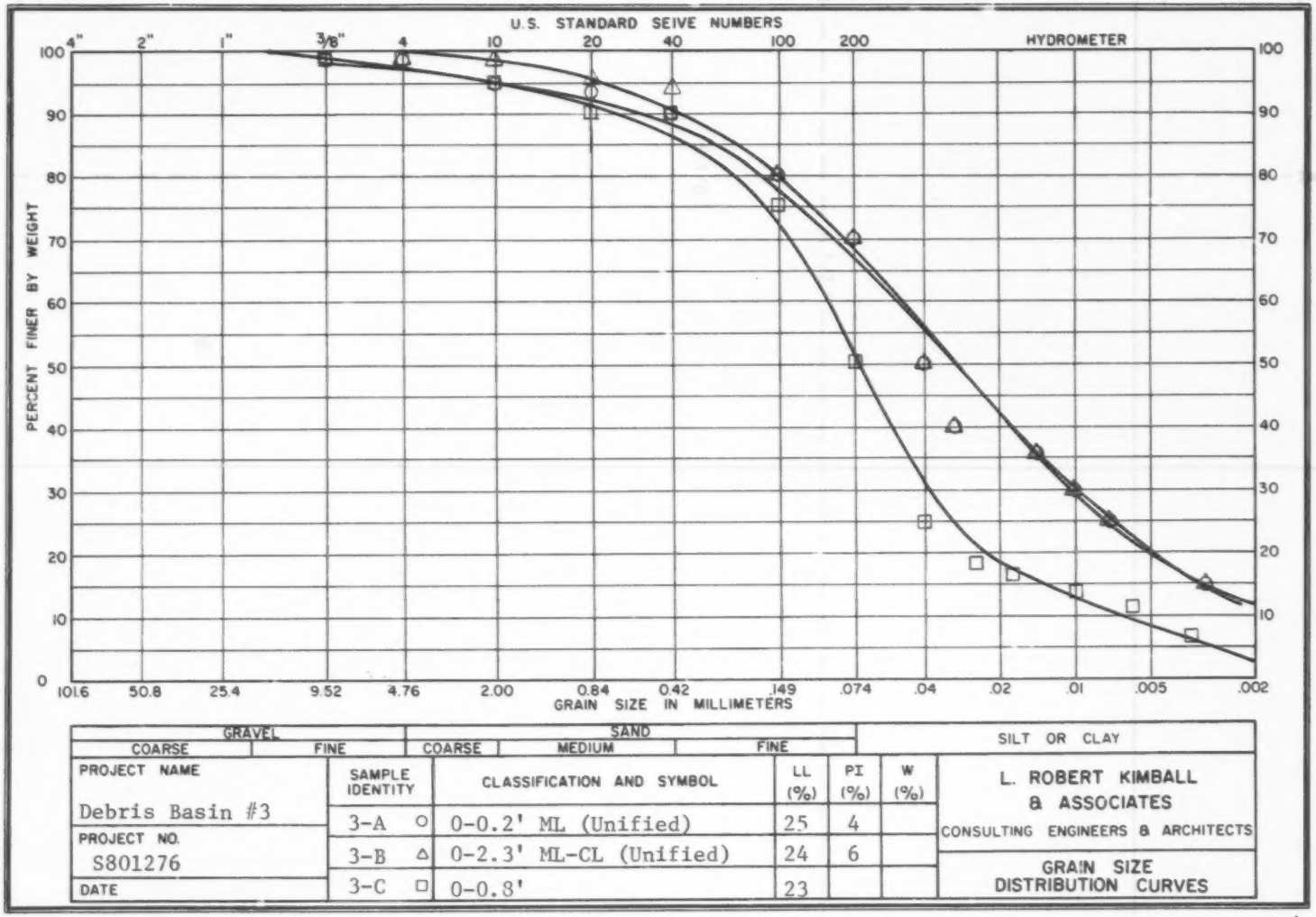
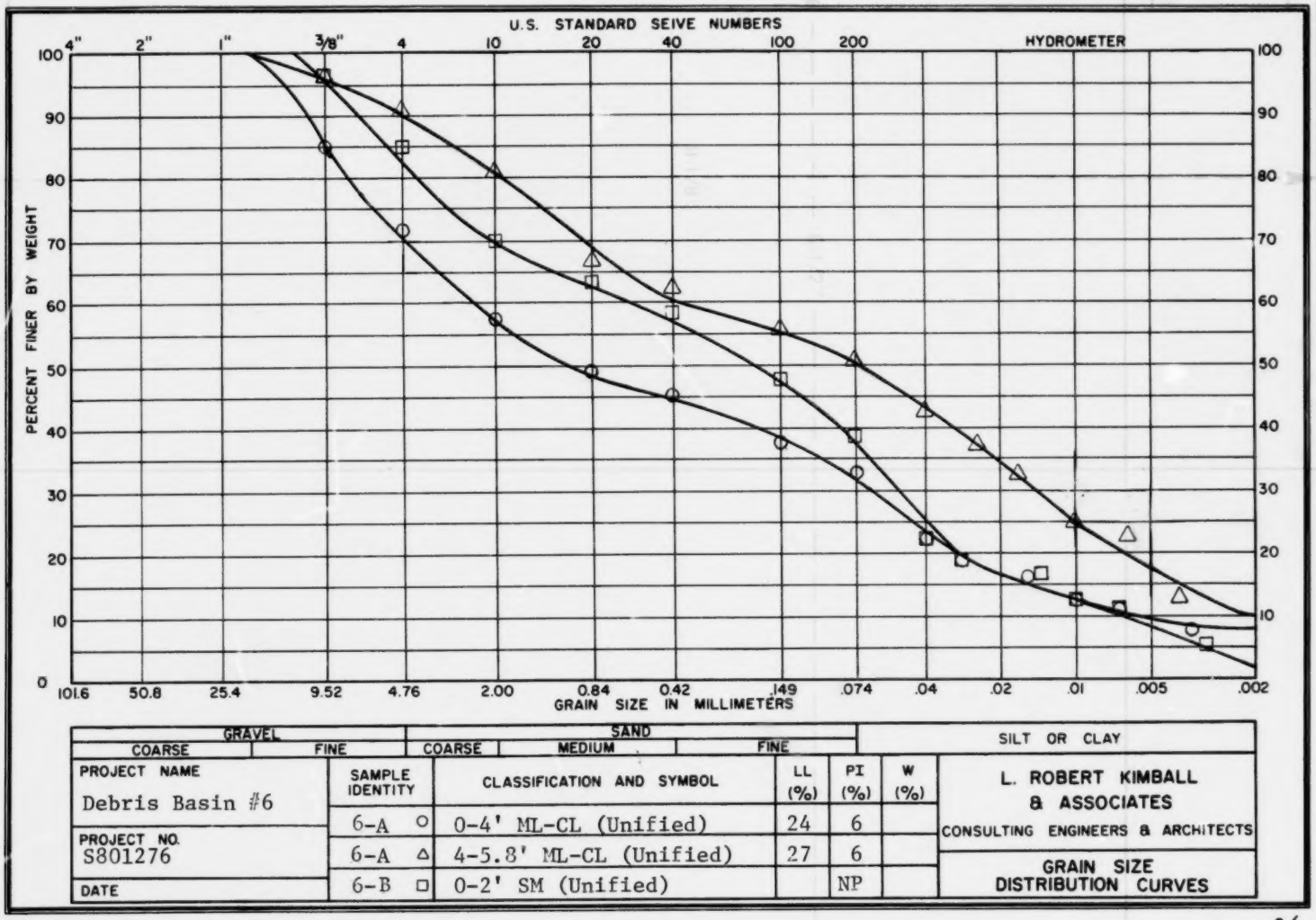


Figure C-6 Grain Size Distribution Curves of Sediment Removed From Basin #3.

2/78


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL COARSE FINE
SAND COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #6
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
6-A ○ 0-4' ML-CL (Unified) 24 6
6-A △ 4-5.8' ML-CL (Unified) 27 6
6-B □ 0-2' SM (Unified) NP
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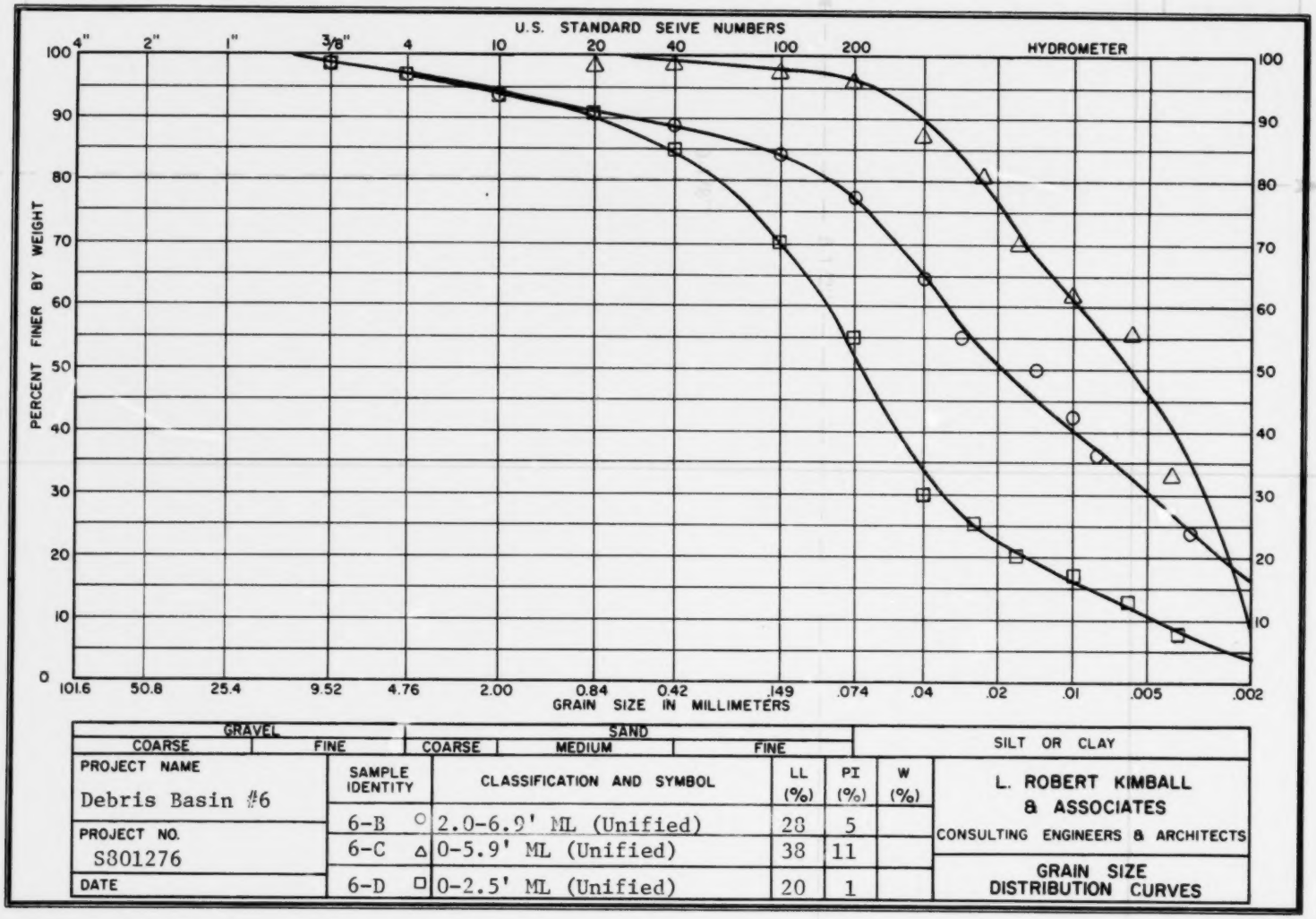
GRAIN SIZE DISTRIBUTION CURVES
2/78

Figure C-7 Grain Size Distribution Curves of Sediment Removed From Basin #6.


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200
HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL COARSE FINE
SAND COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #6
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
6-B ○ 2.0-6.9' ML (Unified) 28 5
6-C △ 0-5.9' ML (Unified) 38 11
6-D □ 0-2.5' ML (Unified) 20 1
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GRAIN SIZE DISTRIBUTION CURVES

Figure C-8 Grain Size Distribution Curves of Sediment Removed From Basin #6.

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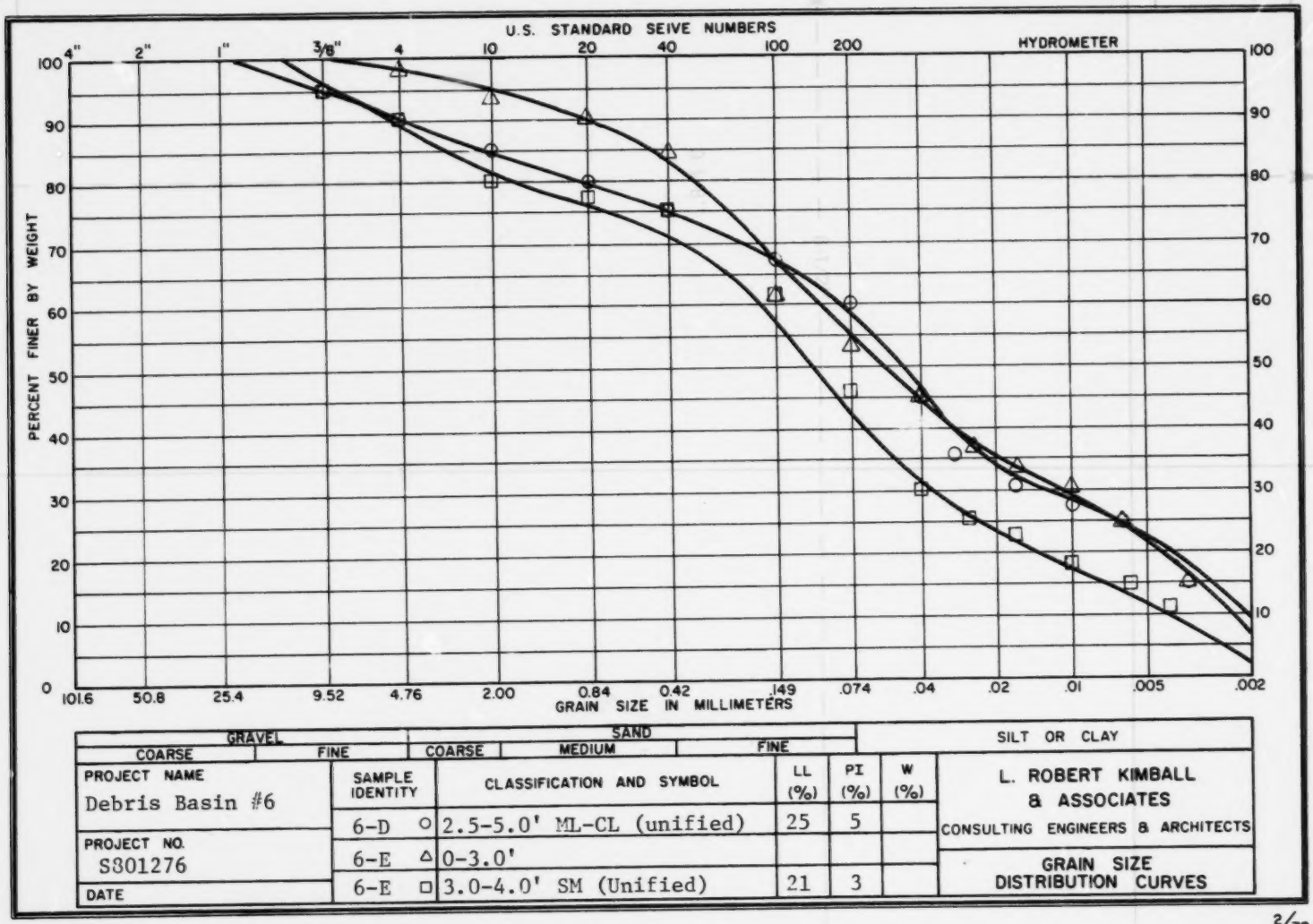
U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL COARSE FINE
SAND COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME Debris Basin #6
PROJECT NO. S301276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%) PI (%) W (%)
6-D ○ 2.5-5.0' ML-CL (unified) 25 5
6-E △ 0-3.0'
6-E □ 3.0-4.0' SM (Unified) 21 3
L. ROBERT KIMBALL & ASSOCIATES
CONSULTING ENGINEERS & ARCHITECTS
GRAIN SIZE DISTRIBUTION CURVES
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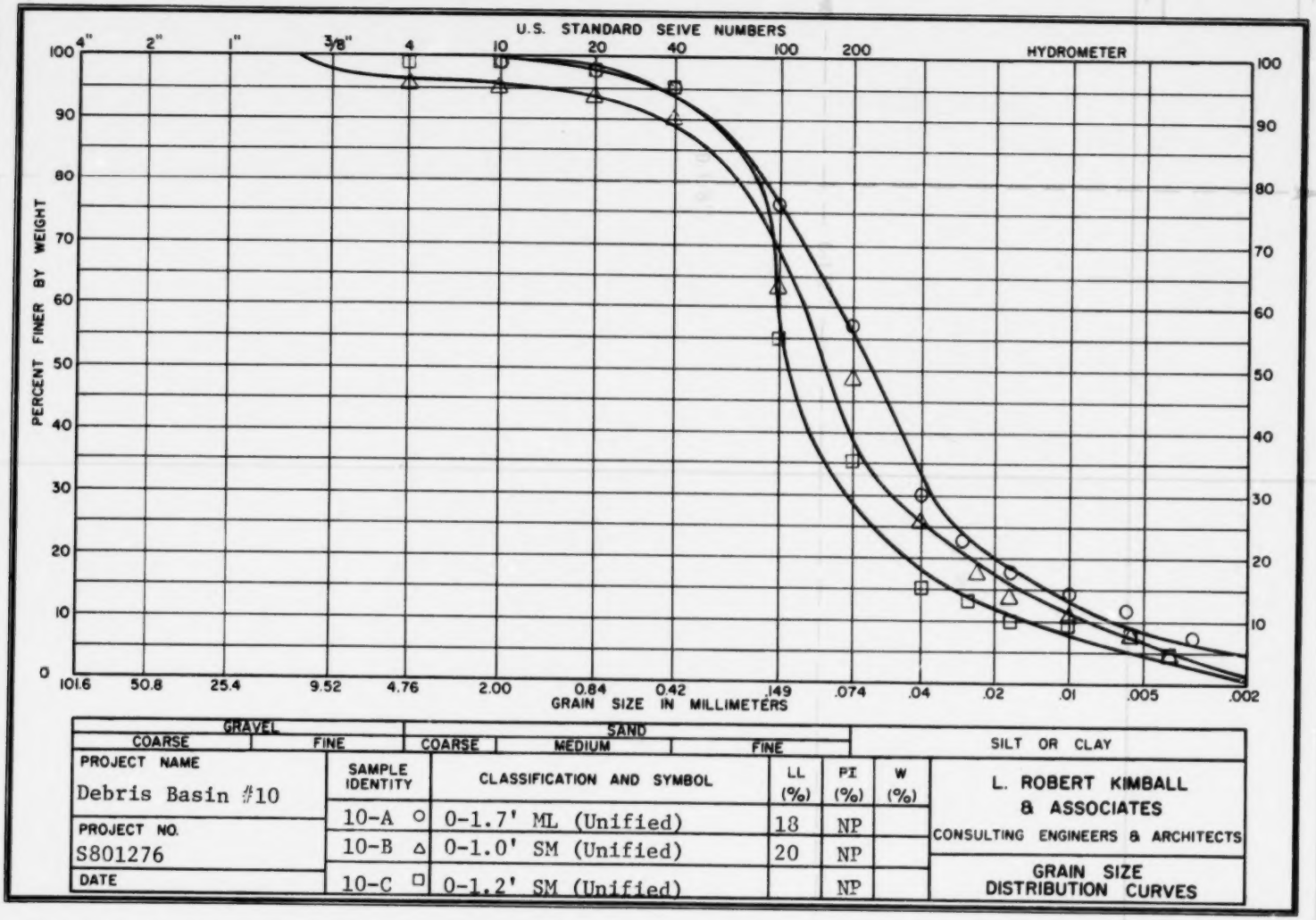
Figure C-9 Grain Size Distribution Curves of Sediment Removed From Basin #6.


U.S. STANDARD SEIVE NUMBERS
4" 2" 1" 3/8" 4 10 20 40 100 200 HYDROMETER
PERCENT FINER BY WEIGHT
100 90 80 70 60 50 40 30 20 10 0
101.6 50.8 25.4 9.52 4.76 2.00 0.84 0.42 .149 .074 .04 .02 .01 .005 .002
GRAIN SIZE IN MILLIMETERS
GRAVEL
COARSE FINE
SAND
COARSE MEDIUM FINE
SILT OR CLAY
PROJECT NAME
Debris Basin #10
PROJECT NO.
S801276
DATE
SAMPLE IDENTITY
CLASSIFICATION AND SYMBOL
LL (%)
PI (%)
W (%)
10-A ○ 0-1.7' ML (Unified) 18 NP
10-B △ 0-1.0' SM (Unified) 20 NP
10-C □ 0-1.2' SM (Unified) NP
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CONSULTING ENGINEERS & ARCHITECTS
GRAIN SIZE DISTRIBUTION CURVES

Figure C-10 Grain Size Distribution Curves of Sediment Removed From Basin #10.

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